



(1) Publication number:

@	EUROPEAN PATENT APPLICATION		
@ @	Application number: 91113048.2 Date of filing: 02.08.91	⊕ Int. CI.5. H01L 21/76, H01L 21/20	
<ul><li>②</li><li>③</li></ul>	Priority: 03.08.90 JP 206548/90  Date of publication of application: 05.02.92 Bulletin 92/06	Applicant: CANON KABUSHIKI KAISHA     30-2, 3-chome, Shimomaruko, Ohta-ku     Tokyo(JP)      Inventor: Yonehara, Takao, c/o Canon	

- Designated Contracting States: AT BE CH DE DK ES FR GB GR IT LI LU NL SE
- Representative: Bühling, Gerhard, Dipl.-Chem. et al Patentanwaitsbüro Tiedtke-Bühling-Kinne & Partner, Bevarlaring 4 W-8000 München 2(DE)

Kabushiki Kaisha

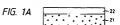
30-2, 3-chome, Shimomaruko Ohta-ku, Tokyo(JP)

- Semiconductor body and process for preparing said semiconductor body.
- A process for preparing a semiconductor member comprises the steps of: forming a member having a non-porous mon-

ocrystalline semiconductor region on a porous monocrystalline semiconductor region, bonding the surface of a member of which the

surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by etching.



#### BACKGROUND OF THE INVENTION

#### Field of tha Invantion

This invanion relatas to a samiconductor member and a process for praparing a semiconductor mamber, more particularly to a samiconductor which it suitable for separation of delectric materials or alactronic devices, integrated cricuits praparad on a monocrystallina semiconductor layar on an insulating material.

#### Related Background Art

Formation of a monocrystallina SI samiconductor layer on an insulating material has been videly known as the silicon on insulator (SOI) technology, and since a large number of advantagas with can not be rasched by bulk SI substitates for praparation of convenional SI integrated circuits are posassed by the davice utilizing the SOI structura, so many rasaarches have been done. More specifically, by utilizing the SOI structura, the following advantages can be obtained:

- 1. Dielectric isolation can be aasily dona to
- anabla high dagrae of integration;
- 2. Radiation hardnass is axcellent;
- Stray capacity is reduced to attain high speed:
- 4. Wall formation step can be omitted;
- Latch-up can be prevented;
- Fully depleted field effect transistor can be made by thin film formation.

In order to realize the many advantages in device characteristics as mentioned above, studies have been made about the method for forming the SOI structura for thesa some 10 years. The contents are summarized in, for example, the literature as mentioned below:

Special Issue: "Single-crystal silicon on nonsingle-crystal insulators"; edited by G.W. Cullan, Journal of Crystal Growth, voluma 63, No.3, pp. 429 - 590 (1983).

Also, it has been known for a long time to form the SOS (allicon on sapphing structure by haterooptiaxy of SI on a monocrystallina sapphira substrate by CVD (chemical support deposition) mathod. This was successful to some axtent as the most natura SI technique, but for such raisons as a large amount of crystal deflects because of lattice mismatching at the Interface between the SI layer and the sapphire substrate, introduction of aliminum from the sapphira substrate into the SI and dalay in anlargament of the substrate water size. It is doctarcted from being widely applicable strategies and charge the substrate water size. It is doctarcted from being widely applied. Raliatively in recent years, attempts to realize the SOI structure without use of a sepphire substrate.

have been done. Such attempts may be broadly classified into the three shown below.

(1) Affar surface oxidation of a SI monocrystal-ina substrate, a window its comed to have tha SI substrate partially axposed, and epitaxial growth is proceeded in the lateral clirection with that axposed portion as the seed to form an SI monocrystallina layar on SiO<sub>2</sub>, (in this casa, deposition of SI layar on SiO<sub>2</sub> is accompanied).

(2) By use of a Si monocrystallina substrata itself as activa layar, SiO<sub>2</sub> is formed therebeneath. (This mathod is accompanied with no daposition of SI layer).

(3) Aftar apitaxial growth of Si on a Si monocrystalline substrate, isolation separation is affected. (This mathod is accompaniad with daposition of Si layar).

As the means for realizing the above (1), there hava been known tha mathod in which a monocrystalline Si layar is formed directly to lataral apitaxial growth by CVD, tha mathod in which amorphous Si Is deposited and subjected to solid phase lateral apitaxial growth by heat treatment, tha mathod in which amorphous or polycrystallina si layar is irradiated convargantly with an enargy beam such as alectron beam, laser beam, atc. and a monocrystalline layar Is grown on SiO2 by malting and recrystallization, and the method in which a melting region is scanned in a zone fashion by a rod-shaped heater (Zone melting recrystallization). These methods have both advantages and disadvantages, the still have many problems with respect to controllability, productivity, uniformity and quality, and none of them have been industrially applied yet up to date. For example, the CVD method requires sacrifice-oxidation in flat thin film formation, while the crystallinity is poor in the solid phase growth method. On the other hand, in the beam annealing method, problems are involved in controllability such as treatment tima by converged beam scanning, the manner of overlapping of beams, focus adjustment, atc. Among thesa, the Zona Meiting Recrystallization method is the most matura, and a ralativaly largar scala integrated circult has been trially mada, but still a large number of crystal defects such as point dafect, lina dafect, plane datect (sub-boundary), atc. ramain, and no davica driven by minority carriars has been prepared.

Concerning tha method using no Si substrata as the seed for epitaxial growth which is the abova method (2), for axampla, the following method may be included:

 An oxida film is formed on an Si monocrystallina substrata with V-groovas as anisotropically atched on the surface, a polycrystallina Si layar is daposited on the oxide film thick to tha axtant as the Si substrate, and thereafter by polishing. from the back surface of the SI aubstrote, SI monocrystalline regions delectrically separed by surrounding with the V-grooves on the thick polycrystalline SI leyer are formed. In this mod, although crystalline is good, there are problems with respect to controlability and produciny in the step of depositing the polycrystalline SI thick as some hundred microns and the step in which the monocrystalline SI substrate is polished from the back surface to leave only the SI active layers.

2. This is the method called SIMOX (Separation by ion-implanted oxygen) in which an SIQs layer is formed by ben implantation of oxygen into an SIQ layer is formed by ion-implantation of oxygen into an side monocrystalline substrate, which is one of the most mature methods because of good method in the side of the

3. This is the method to form an SOI structure by dielectric isolation according to exidation of porous Si. This is a method in which an N-type Si layer is formed on the surface of a P-type Si monocrystailine substrate in shape of Islands by way of proton ion impiantation (imai et al., J. Crystal Growth, Vol. 63,547 (1983)), or by epitaxiei growth and patterning; only the p-type SI substrate is made porous by anodization in HF solution so as to surround the SI Islands from the surface; and then the N-type SI islands are dielectrically isolated by eccelerated oxidation. In this method, the separated Si region is determined before the device steps, whereby there is the problem that the degree of freedom in device and circuit design mey be limited in some CASAS

As the method (8) as described above, the method described in Japanese Laid-open Pethot method described in Japanese Laid-open Pethot Application No. 58-16464 has the steps of forming an N-type monocrystalline 5 lilyer on a P-type SI water, providing a glass layer containing an oxide of the N-type integrity thereon and the step of bonding the glass layer to e glass leyer containing the oxide of an N-puntyl impurity provided on another sition wefer by heat treatment. And, subsequent to the bonding step, the P-type SI wefer is owned; and the step of the

made porous, then oxidized to make the porous layer higher in resistance; e monocrystalline Si leyer is formed on the porous silicon leyer; and a part of the monocrystalline Si leyer is made porous and higher in resistance so as to surround the monocrystalline Si region, thereby separating the monocrystalline Si region.

The methods described in these publications all include the step of oddizing e porous layer and because the volume of porous layer is increased by oxidedon, sometimes an influence of distrion may be exerted on the monocrystaline SI leyer, and therefore in these methods, a monocrystaline SI leyer with constantly good quality could not necessarily be formed on the insuletor.

# SUMMARY OF THE INVENTION

An object of the present invention is to provide e semiconductor member capable of overcoming the problems as described above and meeting the demands as described above and a process for preparing the member.

Another object of the present invention is to provide a semiconductor having a monocrystalline layer excellent in crystallinity equally as moncrystalline SOI water, and a process for preparing the member excellent also in espects of productivtiv, uniformity, controllability economy.

Still another object of the present invention is to provide a semiconductor member having excellent characteristics which can be sufficiently alternative for expensive SOS or SIMOX even in preparing e large scale integrated circuit by the SOI structure and a process for preparing the member economically.

Other objects of the present invention than those as mentioned above are:

to provide e process for preparing e semiconductor member comprising the steps of:

forming e member heving e non-porous monocrystalline semiconductor region on e porous monocrystalline semiconductor region.

bonding the surface of a member of which the surface is constituted of an insuleting substance onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing a semiconductor member comprising the steps of:

forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystelline semiconductor region,

forning a region constituted of an insulating substance on the non-porous monocrystalline semi-conductor side of the member, then

bonding the surface of e member of which the

5 EP 0
surface is constituted of an insulating substance
onto the surface of the region constituted of the
insuleting substance, and

removing the porous monocrystalline semiconductor region by chemical etching;

to provide e process for preparing a semicon-

ductor member comprising the steps of:

making a non-porous monocrystalline semiconductor member porous to form a porous monocrystelline semiconductor region,

forming e non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

bonding the surface of e member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching;

ductor region by chemical etching; to provide e process for preparing a semiconductor member comprising the steps of:

meking e non-porous monocrystalline semiconductor member porous to form a porous mon-

ocrystalline semiconductor region, forming a non-porous monocrystalline semiconductor region on the porous monocrystalline

semiconductor region, forming region constituted of an insuleting substance on the non-porous monocrystalline semicon-

ductor region side, bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the

onto the surface of the region constituted of the insulating substance, and removing the porous monocrystalline semicon-

ductor region by chemical etching; to provide a process for preparing a semiconductor member comprising the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non porous monocrystalline semiconductor region.

forming e third non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

bonding the surface of e member of which the surface is constituted of an insulating substance onto the surface of the third non-porous monocrystalline semiconductor region, and

removing the second non-porous monocrystalline semiconductor region mechanically, and removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing e semiconductor member comprising the steps of:

making a first non-porous monocrystalline semiconductor member partielly porous to form a porous monocrystalline semiconductor region and e second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region,

forming e region constituted of an insulating substance on the third non-porous monocrystalline semiconductor region side,

bonding the surfece of e member of which the surface is constituted of an insuleting substance onto the surfece of the region constituted of the insuleting substance, and

removing the second non-porous monocrystalline semiconductor mechanically, and removing the porous monocrystalline semiconductor region by chemical etching;

to provide e process for preparing e semiconductor member comprising the steps of:

forming a second monocrystalline semiconductor region of e second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making the first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of the second monocrystalline semicon-

ductor region, and removing the porous monocrystalline semiconductor region by chemical etching;

to provide a process for preparing e semiconductor member comprising the steps of:

forming a second monocrystalline semiconductor region of e second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type.

making the first monocrystalline semiconductor region porous to form e porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on the second monocrystalline semiconductor region side.

bonding the surface of e member of which the surface is formed of an insulating substance onto the surface of the second monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching;

to provide a semiconductor member compris-

ing:

e first member heving a non-porous monocrystalline semiconductor region on e porous monocrystalline semiconductor region, and

e second member heving the surface constituted of an insulating substance bonded onto the surface of the non-porous monocrystalline semiconductor region;

to provide e semiconductor member comprisina:

a first member having a non-porous monocrystalline semiconductor region and e region constituted of an insulating substance arranged in this order on e porous monocrystalline semiconductor region, and

a second member bonded through a region constituted of an insulating substance onto the surfece of the region constituted of the insulating substance:

to provide a semiconductor member have onnon-provas silicon monocrystalline semiconducregion arranged on e region constituted of an insuleting substance, cheracterized in that the dislocation defect density in the non-prorus silicon monocrystalline semiconductor region is 2.0 × 10°/cm² or loss, and the life time of carriers is 5.0 × 10<sup>-4</sup> second or longer; and

to provide a semiconductor member having a non-provus silicon monocrystaline semiconductor region arranged on a region constituted of an insuleting substance, characteristed in the the dislocation detect density in the non-provus silicon monocrystaline semiconductor region is 2.0 × 10<sup>4</sup> cm<sup>2</sup> or less, and the life time of carriers is 5.0 × 10<sup>4</sup> cm<sup>2</sup> or longer, and also the difference between the maximum value and the minimum value of the thickness of the silicon monocrystaline semiconductor region is 10% or less with respect to maximum value.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 through 13 are scheniatic illustrations of the examples of the steps of the process for preparing the semiconductor member of the present invention.

# DESCRIPTION OF THE PREFERRED EMBODI-

Preferable semiconductors of the present invention are as described below.

A semiconductor member of the present invention comprises:

a first member having e non-porous monocrystalline semiconductor region provided on a porous monocrystelline semiconductor region, and

a second member having the surface constituted of an insulating substance bonded onto the surface of the non-porous monocrystalline semi-conductor region.

Another semiconductor member comprises:

e first member heving e non-porous monocrystalline semiconductor region and e region constituted of an insuleting substance arranged in this order on a porous monocrystalline semiconductor region, and

e second member bonded through e region constituted of an insulating substance onto the surface of the region constituted of the insuleting substance.

Still another semiconductor member has e nonporous silicon monocrystalline semiconductor region arranged on a region constituted of an insulating substance, wherein the dislocation defect density in the non-porous silicon monocrystalline semiconductor region is 2.0 × 10<sup>4</sup>cm<sup>2</sup> or less, and the life time of carriers is 5.0 × 10<sup>-4</sup> sec or longer.

The time of camers is 5.0 x 10<sup>--</sup> sec or longar. Still exother semiconductor member has a non-porous silicon monocrystalline semiconductor region arranged on e region constituted of an insulating substance, wherein the dislocation defect density in the non-procus silicon monocrystalline semi-conductor region is 2.0 x 10<sup>+</sup>/cm<sup>2</sup> or less, and the file time of carriers is 5.0 x 10<sup>-+</sup>/sec or longar, and also the difference between the maximum value and the minimum value of the thickness of the silicon monocrystalline semi-conductor region is 10.9 x or less, with respect to the maximum value.

Preferable processes for preparing the semiconductor member of the present invention are as described below.

A process for preparing e semiconductor member of the present invention comprises:

forming a member having e non-porous monocrystalline semiconductor region on e porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by chemical etching.

Another process comprises: forming a member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

forming a region constituted of an insulting substance on the non-porous monocrystalline semiconductor side of the member, then

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises: meking a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,

forming a non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region.

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the non-porous monocrystalline

semiconductor region, and removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises the steps of: making a non-porous monocrystalline semiconductor member porous to form a porous mon-

ocrystalline semiconductor region, forming a non-porous monocrystalline semiconductor region on the porous monocrystalline

semiconductor region,
forming a region constituted of an insulating

substance on the non-porous monocrystalline semiconductor region side, bonding the surface of a member of which the surface is constituted of an insulating substance

onto the surface of the region constituted of the insulating substance, and removing the porous monocrystalline semicon-

ductor region by chemical etching.

Still another process comprises the steps of: making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconduc-

tor region,
forming a third non-porous monocrystalline
semiconductor region on the porous monocrystalline semiconductor region.

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the third non-porous monocrystalline semiconductor region, and

removing the second non-porous monocrystalline semiconductor region by mechanical grinding, and removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises the steps of: making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region.

forming a third non-porous monocrystalline semiconductor region on the porous monocrystalline semiconductor region.

forming a region constituted of an insulating substance on the third non-porous monocrystalline semiconductor region side.

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the second non-porous monocrystalline semiconductor by mechanical grinding, and removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprise the steps of: forming a second monocrystalline semiconduc-

tor region of a second conduction type on a first monocrystalline semiconductor region of a first conduction type,

making the first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region.

to forming a region constituted of an insulating material on the second monocrystalline semiconductor region side.

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of the second monocrystalline semiconductor region, and

removing the porous monocrystalline semiconductor region by chemical etching.

Still another process comprises the steps of:

forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making the first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region.

forming a region constituted of an insulating substance on the second monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of the region constituted of the insulating substance, and

removing the porous monocrystalline semiconductor region by chemical etching.

The semiconductor member of the present invention has a monocystalline semiconductor region where carrier life time is long and the defect is actionely little on an insulating material with ox-collent uniformly of thickness, and is applicable to various semiconductor devices. Also, the semiconductor member of the present invention is capable of high speed response, and is applicable to semi-conductor devices rinch in reliability. The semiconductor devices rinch in reliability.

The process for preparing a semiconductor member of the present invention provides a process excellent in aspects of productivity, uniformity, controllability, economy in obtaining an Si crystal layer having crystallinity equal to monocrystalline wafer on an insulation material.

Further, according to the process for preparing a semiconductor member of the present Invention, it is possible to provide semiconductor members wherein the advantages of the SOI device of the prior art can be realized and applied.

Also, according to the present invention, there

can be provided a process for preparing a semiconductor member which can be an alternative for expensive SOS or SIMOX also in preparing a large scale integrated circuit of SOI structure.

The process for preparing a semiconductor member of the present invention, as is described in detail in Examples, makes it possible to perform the treatment efficiently within a short time, and is excellent in its productivity and economy.

Referring now to silicon as an example of semiconductor materials, the present invention is described in detail, but the semiconductor material in the present invention is not limited to silicon at

In porous Si layer, according to observation by transmission electron microscopy, pores with diameters of about 600 angstroms on an average are formed, and despite the fact that their density is half or lower as compared with monocrystalline silicon, momocrystallinity is maintained. Monocrystal refers to a crystalline solid such that, when calling attention on an optional crystal axis, its direction is the same at any part of the sample. and the porous layer used in the present Invention, although having pores therethrough, the crystal axis in the crystalline region is the same in the direction at any part, thus being monocrystalline And, epitaxial growth of a monocrystalline Si layer onto the porous layer is possible. However, at a temperature of 1000 °C or higher, rearrangement of the atoms positioned around the inner pores takes place, whereby the characteristics of accelerated chemical etching may be sometimes impaired. For this reason, in the present invention, for epitaxial growth of Si layer, there may be suitably used the crystal growth method capable of low temperature growth such as molecular beam epitaxial growth, plasma CVD, low pressure CVD method, photo CVD, bias-sputtering method, liquid phase growth method, etc.

Since the porous layer has a large amount of void, formed internally thereof, its density can be reduced to half or lower. As the result, the surface area per unit volume (specific surface area) can be dramatically increased, and therefore its chemical etching rate is remarkably accelerated as compared with that of the etching rate of conventional non-porous monocrystalline layer. The present invention utilizes the two above-mentioned characteristics of the semiconductor as made porous, namely the fact that single crystallinity is maintained and a non-porous semiconductor monocrystal can therefore be epitaxially grown on the semiconductor substrate as made porous, and the fact that etching rate is remarkably more rapid as compared with non-porous monocrystal, whereby a non-porous semiconductor monocrystalline layer of high quality can be formed on a substrate having an insulating material surface within a short time.

The porous layer can be more readily formed on a P-type Si layer than an N-type Si layer for the following reason. First, a porous Si was discovered by Uhlir et al. in the research process of electrolytic polishing of semiconductor in 1956 (A. Uhlir, Bell Syst, Tech. J., vol 35, p.333 (1956)).

Unagami et al. studied about the dissolving reaction of Si in anolization, and has reported that positive holes are necessary for the anodic reaction of Si in an HF solution, and the reaction is as follows (T. Unagami, J. Electrochem. Soc., vol. 127, p. 476 (1980)).

Here, e<sup>\*</sup> and e<sup>\*</sup> represent a positive hole and an electron, respectively. n and λ are respectively numbers of positive holes necessary for dissolving one atom of silicon, and it has been postulated that porous silicon is formed when satisfying the condition of n ≥ 2 or λ > 4.

For the reasons mentioned above, the P-type silicon in which positive holes exist will be more readily made porous than the H-type silicon of the opposite characteristic, Selectivity in such pore structure formation has been verified by Nagano et al. (Nagano, Nakajima, Yasuno, Ohnaka, Kajiwara; Denshi Tsushin Gakka Gijitus Kenkyu Holokou, vo. 79, SSD 79-9549(1979) and Imal, K. Imai; Solid-State Electronics vol. 24, 159 (1981). However, depending on the conditions, the N-type silicon can be also made opcorus.

Referring now to the drawings, the present invention is described in more detail.

# 45 Embodiment 1

Description is made about the process for obtaining a semiconductor substrate by making porous all of a P-type substrate and permitting a monocrystalline layer to be epitaxially grown.

As shown in Fig. 1A, first a P-type Si moncrystaline substrate is provided, and all of it is made porous. According to the crystal growth method capable of low temperature growth as mentioned above, epitaxial growth is effected on the substrate surface as made porous to form a thin film monocrystalline layer 22. The above Ptype Si substrate is made porous by the anotization method by use of an HF solution. The porous Si layer 21 can be varied in its density to a range of 1.1 to 0.8 g/cm<sup>3</sup> by varying the HF solution concentration to 50 to 20% as compared with the density 2.33 g/cm<sup>3</sup> of the monocrystalline SI.

Subsequently, as shown in Fig. 1B, by providing another Si substrete 23 and after forming an oxidized layer 24 on its surface, the Si substrate 23 having the oxidized layer 24 on the surface Is bonded onto the surfece of the monocrystalline layer 22 on the porous Si substrate 21. Then, as shown in Fig. 1C, the porous SI substrete 21 is all etched away to form a thin film-like monocrystalline silicon laver 22 remaining on the SiO2 laver 24. In the present invention, since the porous semiconductor layer is etched away without application of the oxidation treatment on the porous semiconductor leyer, the oxidetion swelling of the porous semiconductor layer can be prevented, whereby the influence of distortion on the monocrystalline layer es epitaxielly grown cen be prevented. According to this method, the monocrystalline Si layer 22 equal to sillcon water in crystallinity is formed flat and yet uniformly thinly over the whole wefer region with a large area on the oxidized Si layer 24 which is an insulating material. The semiconductor substrete thus obtained can be suitably used also with respect to preparation of an insulation separated electronic device.

Here, the thickness of the non-porous semiconductor crystalline layer to be formed on the porous semiconductor substrate may be desirably made preferably 50 km or less, more preferably 20 km or less, for forming a this film semiconductor device on the above semiconductor monocrystalline layer.

Bonding between the above non porous semiconductor monocrystal and the substrete having the insuleting meterial surface should be preferably performed in en atmosphere of nitrogen, an inert gas or e gas mixture of these, or in an etmosphere containing an inert gas or nitrogen, and further desirably under heeted state.

As the etchant for selectively etching the above semiconductor substrete se made porous with the above non-porous semiconductor monocrystalline layer as bonded onto the substrate heiving the insulating material surface being left to remain, for example, there may be employed etchants such as aqueous sodium hydroxide solution, aqueous potassium hydroxide solution, aqueous potassium hydroxide solution, hydrofluoric acid-nitiric acid-acetic acid mixed solution, acid-nitiric acid-acetic acid mixed solution.

The substrate having an insulating material which can be used in the present invention may one with at least its surface being constituted of an insulating material, or one with all of the substrate being constituted of an insulating material. Examples of the substrate with the surface being constituted.

stituted of an insultating materiel may include moncorystalline or polycrystalline silicon substrates having the surface oxidized, electroconductive or semiconductive substrates having a layer of en insultating material such as oxide, nitride, boride, act. formed on the surface, etc. Specific examples of the substrates wholly constituted of an insultating material may include substrates comprising insultaing material may include substrates comprising insultaing material may include substrates or comprising insulta-

Meanwhile, in the present Embodiment 1, an example of forming a non-porous semiconductor monocrystalline layer on a porous semiconductor monocrystalline layer on a porous semiconductor substrate has been shown, but the present invention is not limited only to the mode of the Embodiment 1 as described above, but a porous semi-conductor substrate heving e non-porous semiconductor unbarrath heving e non-porous semiconductor monocrystalline layer me be also formed by applying e pore forming treatment on a substrate having a monocrystalline layer comprising a material which can be made porous with difficulty (e.g. N-type silicon), and a layer complising a material which can be madily made porous (e.g. P-type silicon).

Also, in the step of removing the procus semiconductor substrate by etching, the substrate symbel also coased with an etching preventive meteriel except for the provus semiconductor substrate languages, and ing etching, so that the non-porous semiconductor monocrystalline layer and the substrate having insulating material surface may not be deleteriously influenced by the etchant.

The non-porous monocrystalline leyer on the insulating material thus formed can be one having 5.0 x 10-4 sec. or longer in terms of the life time or carriers, heving remarkably less crystal defect such as through dielocation, etc. and also being extremely smell in distribution of the layer thickness of the semiconductor monocrystalline layer. Specifically, the dislocation defect density becomes 2 x 104/cm2 or less, and concerning the leyer thickness of the semiconductor monocrystalline layer, within the range of the aree of the semiconductor monocrystalline leyer from 20 cm2 to 500 cm2 (2 Inches wafer to 10 Inches wafer), the difference between the maximum value and the minimum value of the thickness of the semiconductor monocrystalline layer can be suppressed below 10% or less based on the maximum value.

in the following, other embodiments are shown.

# Embodiment 2

Referring now to Figs. 2A to 2D, Embodiment 2 is described in detail.

First, as shown in Fig. 2A, a low impurity concentration leyer 122 is formed by epitaxial growth according to various thin film growth meth-

ods. Alternatively, protons may be ion implanted into the surface of the P-type Si monocrystalline substrate 121 to form an N-type monocrystalline layer 122.

Next, as shown in Fig. 28, the back surface of the P-type monocytatiline substrate 121 is denatured into a porous Si substrate 123 according to the anodization method by use of an HF solution. The porous Si layer 123 can be varied in its density to a range of 1.1 to 0.6 g/cm² by varying the HF solution concentration within the range of 50 to 20%, as compared with the density of the monceytetatine Si or 2.33 g/cm². The porous layer, set described above, is formed on the P-type sub-

As shown in Fig. 2C, by providing another Si substrate 124 and efter forming an oxidized leyer 125 on its surface, the Si substrate 124 heaving the oxidized leyer 125 on its surface is bonded to the surface of the monocrystalline Si leyer 122 on the norrous Si substrate 123.

Then, the porous Si substrate 123 is all etched to leeve a monocrystalline silicon layer 122 as thin film on the SiO<sub>2</sub> layer 125, thereby forming e semiconductor substrate.

According to this process, the monocrystalline stormed on the oxidized layer 125 which is an insuleting material to be flat and to be yet made uniformly into thin layer, over the whole water region with a large aree.

The semiconductor substrete thus obtained can be used suitably also with respect to preparation of en insulation separeted electronic device.

The above Embodiment 2 is an example of the process of forming an N-type layer on e Pype substrete before pore formellon, and then meking selectively only the P-type substrete porous selectively only the P-type substrete have selected and the present Embodiment, as semiconductor substrate having e semiconductor monocrystalline leyer with the same performances as Embodiment 1 can be obtained.

# Embodiment 3

As shown in Fig. 3A, first a P-type Si monocrystalline substrate is prepared and all of it is made porous. According to various growth methods, epitaxiai growth is effected on the substrate surface made porous to form a thin film moncrystalline laver 12.

As shown in Fig. 3B, by preparing another Si substrate 13 and after forming an oxidized layer 14 on its surface, the SI substrate having the oxidized layer 14 on the surface is bonded to the surface of the monocrystalline SI layer 12 on the porous SI substrate 11.

Next, as shown in Fig. 3B, an Si<sub>2</sub>N<sub>4</sub> leyer 15 is

deposited to cover over the whole of the bonded how allicon weaters as the anti-electring film. Subsequently, as shown in Fig. 3C, the Sish, leyer on the surface of the porous elicon substrate is removed. As another anti-elothing film material, Apiezon Wax may be elso employed in place of Sish. Then, the porous SI substrate 11 is all etched and a monocrystallian silicon leyer 12 mode into eithin film remains on the SiQ layer 14 to 1

form a semiconductor substrate. Fig. 3C shows a semiconductor substrate obtained in the present Invention. More specifically, by removing the Si<sub>3</sub>N<sub>4</sub> leyer 16 as the anti-etching film in Fig. 3B, e monocrystalline SI leyer 12 of which crystallinity in equal to that of bulk wefer is formed through the SiO2 layer 14 which is en insulating substance on the Si substrete 13, flat and yet uniformly into e thin leyer, over the whole wafer region with e large area. The semiconductor substrete thus obtained can be used suitably elso with respect to preperetion of e discrete insulated electronic device. Also in the present Embodiment, e semiconductor substrete having a semiconductor monocrystalline leyer with the same performances as Embodiment 1 can be obtained.

#### Embodiment 4

Referring now to Figs. 4A to 4B, the Embodiment 4 of the present invention is described below in detail.

First, as shown in Fig. 4A, e low impurify concentration leyer 112 is formed by epitaxial growth according to various thin film growth methods. Alternatively, protons may be ion-implained into the surface of the P type Si monocrystalline substrate 111 to form an N-type monocrystalline leyer 112.

Next, as shown in Fig. 48, the back surface of the P-type monocrystaline substrate 111 denancery of the P-type monocrystaline substrate 113 according to the anodization method by use of an HF solution. The porous Si sayer 113 can be varied in its density to a range of 1.1 to 0.6 (p/m² by varving a the HF solution concentration to 60 to 20% as compared with the density of the monocrystaline Si of 2.33 g/cm². The porous layer 113, of described above, is formed from the P-type substrate sorting the property of the monocrystaline Si of 2.33 g/cm². The porous layer 113, of described above, is formed from the P-type substrate.

As shown in Fig. 4C, by preparing another SI substate 114 and after forming an oxidized layer 115 on its surface, the SI substrate 114 having the oxidized leyer 115 on the surface Is bonded on the surface of the monocrystalline SI leyer 112 on the porcus SI substrate 113.

Here, as shown in Fig. 4C, as the anti-etching film 118, an Si<sub>3</sub>N<sub>4</sub> layer 116 is deposited to cover over the whole of the bonded two silicon waters as the anti-etching film. Subsequently, as shown in

Fig. 4C. the SINL leyer on the surface of the porous silicon substrate is removed. As another anti-etching film 116, or material excellent in etching resistance such as Aplexon Wax may be also employed in piace of Sisht. Then, the porous Sisubstrate by teating a monocytailine silicon injer 112 made into a thin film on the SIQ: layer 115. Fig. 4D shows a substrate by variable silicon injer or total or the silicon silicon in the present invention. That is, by removing the SINL layer 116 as the anti-etching film 118 shown in Fig. 4C, or monocrystalline SI layer 112 is formed on the SIQ: layer 115 which is the insulating meterial, filet and yet uniformly into a thin layer, over the whole water region with a large of the layer.

The semiconductor thus obtained will not be deleteriously affected by the atchant, and can be used suitably also with respect to preparation of a discrete insulated electronic device.

Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

#### Embodiment 6

As shown in Fig. 5A, first, a P-type sI monorystalline substrate is prepared and all of it is made porous. A thin film monocrystalline layer 32 is formed by effecting epitaxial growth on the substrete surface mede porous eccording to various growth methods.

As shown in Fig. 5B, by preparing another Si substrate 33 and after forming an oxidized leyer 34 on its surface, the Si substrate 33 heving the oxidized layer 34 on the surface is bonded to the surface of the oxidized layer 36 formed on the monocrystalline SI layer 32 on the porous substrate 31. The bonding step is practiced by closely contacting the cleaned surfaces with each other, foilowed by heeting in an Inert gas atmosphere or nitrogen atmosphere. The oxidized lever 34 is formed in order to reduce the interface level of the non-porous monocrystalline lever 32 which is the final active layer. As shown in Fig. 5B, an SiaNe lever 35 is deposited as the anti-etching film to be coated on the bonded two silicon waters as a whole. Subsequently, as shown in Fig. 5C, the SlaN4 layer 35 on the surface of the porous silicon substrate 31 is removed. As another anti-etching film meterial, Apiezon Wax, etc. may be also employed in place of SiaNs. Then, all of the porous Si substrate 31 is etched to have the monocrystalline silicon layer 32 mede into e thin film remain on the SiO<sub>2</sub> lever, thereby forming e semiconductor sub-

Fig. 5C shows the substrete having the semiconductor lever obtained in the present invention. More specifically, by smoving the Sish. Issue 35 as the anti-etching files shown in Fig. 58, the mon-corystalline Si leyer 32 equal in crystalline Si leyer 32 equal in crystalline Si leyer 32 equal in crystalline Si leyer 34 and 39 on the Si substreas 33, fiet and yet uniformly into the line leyer, over the whole safer region with a large area. The semiconductor substreas thus obtained can be used satisfatly also with respect to preparation of a discrete insulated electronic device. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as the obtained in Embodiment.

#### Embodiment (

Referring now to Figs. 6A to 6D, the Embodiment 6 of the present invention is described below in detail.

First, as shown in Fig. 8A, a low impurity concentration layer 132 is formed by optization growth according to various thin film growth methods. Alternatively, the surface of the P-type 8I monoccystalline substrate 131 is subjected to ion implantation of protons to form an N-type monocrystalline layer 132.

Next, as shown In Fig. BB, the P-type Si moncorptaline substrate 131 is denatured from the back surface to a porous SI substrate 133 by the anodization method with an HF solution. The porous SI layer 133 can be varied in its denertly in the range of 1.1 to 0.8 giarr by varied in its denertly in the range of 1.1 to 0.8 giarr by varied with the the deneity of the monocrystalline SI of 2.33 giarn. The porous layer, as described above, is formed from the P-type substrate.

As shown in Fig. 6C, by preparing another SI substrate 134 and efter forming an oxidized layer 135 on its surface, the Si substrate 134 having the oxidized layer 135 is bonded onto the surface of the oxidized layer 137 formed on the monocrystalling Si layer 132 on the porous Si substrate 133.

Subsequently, as the anti-etching film 138, an SIN. layer 138 in deposited to be casted on the bonded two silicon welers as a whole. Then, as shown in Fig. 60, the SIN. layer 138 on the surface of the porous silicon substrate 133 is removed. Then the porous is substrate 133 is removed. Then the porous SI substrate 133 is refunded, which is not supported to the substrate 135 is refunded, which is not supported to the substrate 135 is refunded, which is not supported to the film remain on the SIO<sub>2</sub> layers 135 and 137, thereby forming a semiconductor substrate.

The semiconductor substrate thus obtained is excellent in adhesion between the respective leyers, and can be elso used suitable also with respect to preparetion of an isolation separeted elsotronic device. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

#### Embodiment 7

As shown In Fig. 7A, first, a P-type Si monocrystalline substrate is prepared and all of it is made porous. According to various growth methods, epitaxial growth is effected on the substrate surface made porous to form a thin film monocrystalline layer 42. As shown in Fig. 7B, by preparing another Si substrate 43 and after forming an oxidized layer 44 on its surface, the Si substrate 43 having the above oxidized layer 44 on the surface is bonded onto the surface of the oxidized layer 45 formed on the monocrystalline SI layer 42 on the porous Si substrate 41. This bonding step is practiced by closely contacting cleaned surfaces with each other, followed by heating in an inert gas atmosphere or nitrogen atmosphere. The oxidized layer 44 is formed in order to reduce the interface level of the monocrystalline layer 42 which is the active layer as the final semiconductor. As shown in Fig. 7C, the porous Si substrate 41 Is all etched to have the monocrystalline silicon layer made into a thin film on the SiO2 layers 44 and 45, thereby forming a semiconductor substrate. Fig. 7C shows the semiconductor substrate obtained in the present invention

A monocrystalline Si layer 42 equal in crystallimity to silicon water is formed through the SiO<sub>2</sub> layers 44 and 45 on the Si substrate 43, flat and yot uniformly into a thin layer, over the whole water region with a large area. The semiconductor substrate thus obtained can be also used suitably also as seen from the stranspoint of preparation of an isolation separated alektron device. Also, the semiconductor substrate obtained in the present emtangle of the semiconductor substrate obtained in the present emtangle of the semi-properties of the semi-properties of the strategies of the semi-properties of the semi-properties of the strategies of the semi-properties of the

#### Embodiment 8

Referring now to Figs. 8A to 8D, the Embodiment 8 of the present invention is described below in detail.

First, as shown in Fig. BA, a low impurity concentration layer 142 is formed by epitaxial growth according to various thin tilm growth methods. Alternatively, the surface of the P-type Si monocrystalliae substrate 141 is subjected to implantation of protons to form an N-type monocrystalline layer 142.

Next, as shown in Fig. 8B, the P-type SI moncrystalline substrate 141 is denatured from the back surface to a porous SI substrate 143 by the anodization method with an HF Solution. The porous SI layer 143 can be varied in its density in the range of 1.1 to 0.6 g/cm² by varying the HP solution concentration to 50 to 20% as compared with the density of the monocrystalline SI of 233 g/cm². The porous layer, as described above, is formed on the P-type substrate 141.

As shown in Fig. 8C, by preparing another Si substrate 144 and after forming an oxidized layer 145 on its surface, the Si substrate 144 having the oxidized layer 145 is bonded onto the surface of the oxidized layer 146 formed on the monocrystine line Si layer 142 on the porous Si substrate 143.

Than the porous SI substrate is all chemically etched to have a monocrystalline silicon layer made into a thin film remain on the SiO<sub>2</sub> layers 145 and 146, thereby forming a semiconductor substrate.

Fig. 80 shows the semiconductor substrate obtained in the present invention. A monocrystalline SI layer 142 equal in crystallinity to silicon water is formed through the SIO<sub>2</sub> layers 145 and 146 on the SI substrate 144, flat and yet uniformly into a thin layer, over the whole water region with a large area.

The semiconductor substrate thus obtained can be also used suitably also with respect to preparation of an isolation separated electronic device. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

# Embodiment 9

As shown in Fig. 9A, first, a P-type Si monocrystalline substrate is prepared, and all of it is made porous. According to various growth methods, epitaxial growth is effected on the surface of the substrate S1 made porous to form a thin film monocrystalline layer 52.

As shown in Fig. 9B, a light-transmissive substrate 53 represented by glass is prepared and the light-transmissive substrate 53 is bonded onto the surface of the monocrystalline SI layer 52 on the porcus SI substrate 51.

Here, as shown in Fig. 8B, as the anti-etching film 54, an 58h, layer 54 is deposited to be coasted on the bonded two substrates as a whole. Subsequently, as shown in Fig. 95, the 58h, layer 54 on the surface of the porous 51 substrate 51 is all esthed away to have a monocrystalline silicon layer 52 made into a thin film remain on the light-transmissive substrate 53, threatly forming a semi-conductor substrate. Fig 90 shows the semi-conductor substrate. Fig 90 shows the semi-conductor substrate.

The semiconductor substrate thus obtained can be also used suitable also as seen from the stand-point of preparation of an electronic device isolation separated with a light-transmissive insulating material. Also, the semiconductor obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

#### Embodiment 10

Referring now to Figs. 10A to 10D, the Embodiment 10 of the present invention is described below in detail.

First, as shown in Fig. 10A, a low Impurity concentration layer 152 is formed by epitaxial growth according to various thin film growth methods. Alternatively, the surface of the P-type Si monocrystalline substrate 151 is subjected to implantation of protons to form an N-type monocrystalline juver 152.

Next, as shown in Fig. 108, the P-type SI monocrystalline substrate 151 is donatured from the back surface to a porous SI substrete 153 by the anodization method with an HF solution. The porous SI layer 153 can be varied in its density in the range of 1.1 to 0.8 g/cm³ by varying the HF solution concentration to 90 to 20% as compared with the density of the monocrystalline SI of 2.33 g/cm³. The porous layer 153, as described above, is formed on the P-type substrate 151.

As shown in Fig. 10C, after preparing a lighttransmissive substate 154, not the surface of the monocrystalline Si layer 152 on the porous Si substrate 153 is bonded the light-transmissive substrate 154. Then, as shown in Fig. 10C, as an amietching film 155, an Si<sub>2</sub>N<sub>1</sub> layer, oct. is deposited to be coated on the bonded two substrates as a whole. Subsequently, as shown in Fig. 100, the whole. Subsequently, as shown in Fig. 100, the Si<sub>2</sub>N<sub>1</sub> layer 155 on the surface of the porous silicon substrate 153 is removed. Then, the porous Si substrate 153 is all etched away to have the moncrystalline silicon layer 152 made into a thin film remails on the light-transmissive substrate 154, thereby forming a semiconductor substrate,

Fig. 10D shows the semiconductor substrate obtained in the present invention. It is the mon-corystalline Si layer 152 equal in crystallinity to silicon water formed on the light-transmissive substrate 154, flat and yet uniformly into a thin layer, over the whole water region with a large area.

The semiconductor substrate thus obtained can be also used suitably also with respect to proparation of an isolation separated electronic device with a light-transmissive insulating material. Also, the semiconductor substrate obtained in the present Embodiment has the same performances as that obtained in Embodiment 1.

#### Embodiment 11

As shown in Fig. 11A, first e P-type Si moncrystalline substrate is prepared, and all of it is made porous. According to various growth methods, epitaxial growth is effected on the surface of the substrate 51 made porous to form a thin film monocrystalline layer 62. As shown in Fig. 11B, e light-transmissive substrate 63 represented by glass is prepared and the light-transmissive substrate 63 is bonded to the surface of the monocrystalline Si leyer 62 on the propus Si substrate 61.

Then, the porous SI substrate 61 is all etched to have the monocrystalline silicon layer 62 made into e thin film remain on the light-transmissive substrate 63, thereby forming e semiconductor substrate.

Fig. 11C shows the semiconductor substrete obtained in the present invention. It is the mon-corystalline Si layer 82 equal in crystallinity to silicon water formed on the light-transmissive substrate 83, flat and yet uniformly into a thin leyer, over the whole welter region with the large area. The semiconductor thus obtained can be also suitably used also with respect to properation of an electronic device isolation separated with e light-transmissive insulation material.

#### Embodiment 12

Referring now to Figs. 12A to 12D, the Embodiment 12 of the present invention is described below in detail.

First, as shown in Fig. 12A, a low impurity concentration layer 182 is formed by epitaxial growth according to various thin film growth methods. Alternatively, the surface of the P-type SI monocrystalline law substrate 161 is subjected to ion implantation of protons to form an N-type monocrystalline layer 182.

Nost, as shown in Fig. 128, the P-type SI monocrystalline substrate 181 is denatured from the back surface to a porous SI substrate 183 by the anodization method with an HF solution. The porous SI layer 163 can be varied in its density in the range of 1.1 to 0.8 g/cm³ by varying the HF solution concentration to 50 to 20% as compared with the density of the monocrystalline SI of 2.3 g/cm³. The porous layer 183, as described above, is formed on the P-type substrate 163.

As shown in Fig. 12C, after preparing a lighttransmissive substrate 164, onto the surface of the monocrystalline SI layer 162 on the porous SI substrate 163 is bonded the light-transmissive substrate 164. As shown in Fig. 12C, the porous SI substrate 163 is all etched away to have the moncorystalline sillon layer 162 made into a thin film remain on the light-transmissive substrate 184, thereby forming a semiconductor substrate.

Fig. 12D shows the semiconductor substrate obtained in the present invention. It is the monocrystalline Si layer 162 equal in crystallinity to silicon water formed on the light-transmissive substrate 164, flat and yet uniformly into a thin layer, over the whole water region with a large are.

The semiconductor substrate thus obtained can be also used suitably also with respect to preparation of an isolation separated electronic device with a light-transmissive insulating material. Also, the semiconductor substrate obtained in the present Embodiment has the same performances so that obtained in Embodiment 1.

# Embodiment 13

This Embodiment is described by referring to Figs. 13A. to 13 Fig. 13A, forst a procus region 1301 is formed on a part of an Si monocrystalline substrate 1300. Subsequently, a thin tim Si monocrystalline layer 1302 is formed according to various crystal growth method on the procus region 101 (Fig. 13B). On the thin fill is monocrystalline layer 1302 is formed an oxidized fill 1303 (Fig. 13C).

The oxidized film 1305 formed on the surface of another Si substrate 1304 is bonded to the above oxidized film 1303 (Fig. 13D).

Subsequently, the SI monocrystalline substrate 1300 remaining without being mode porous is removed by mechanical polishing or etching to have the porous region 1301 exposed (Fig. 13E).

The porous region 1301 is etched away to form a semiconductor substrate having a thin film Si monocrystalline layer on an insulating material (Fig. 13F).

When such step is employed, the time required for making the substrate porous can be shortened and also the time for etching away the porous Si substrate can be shortened, whereby substrate formation can be effected highly efficiently.

It is also possible to bond the thin film Si monocrystalline layer 1902 directly to the oxidized film 1305 without forming the oxidized film 1905 shown in Fig. 13, and it is also possible to bond an insultating substrate such as glass, etc. In place of the oxidized film 1305 formed on the Si substrate 1904.

Also, the respective steps in the Embodiments 1 to 12 can be also incorporated in the present Embodiment.

The semiconductor substrate thus obtained has the same excellent performances as those of the semiconductor substrate obtained in Embodiments 1 to 12

#### Example 1

A P-type (100) monocrystalline Si substrate (Si wafer) having a diameter of 3 Inches and a thickness of 200 microns was anodized In a 50% HF solution. The current density at this time was 100 mA/cm². The porous structure formation rate at this

time was 8.4 µm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 21 was grown an Si epitaxial layer to a thickness of 0.5 microns by the MBE (Molecular Beam Epitaxy) method. The deposition conditions are as follows:

Temperature: 700 °C
Pressure: 1 x 10<sup>-9</sup> Torr
Growth rate: 0.1 nm/sec.

Next, on the surface of the optizadal suyer 21 was superposed another SI substrate 23 with an oxidized layer of 5000 engstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 5 hour, the two SI substrates were bonded firmly together. Then, the porous SI substrate 21 was chemically etched away by use or hydrofluoric scid-nitric scid-sceeds acid solution (13-28).

As described above, chemical exhining rate of ordinary SI monocrystal relative to hydroflucion caldrative acid-acede cod solution is about a little lower than 1 micron per minute hydroflucion caddristric acid-acede acid solution 1.30, but the chemical exhining rate of a porous layer is accelerated by about-100-fed hereof. That is, he SI substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a monocrystalline Si layer 22 having a thickness of 0.5 μm could be formed on the SiO<sub>2</sub> layer 24.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer, Specifically, the whole surface of the 3 inches wafer was scanned for the measurement. As the result, within the plane of the 3 Inches water, the difference between the maximum value and the minimum value of the thickness of the monocrystalline SI layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline SI layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less. whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0 x 10-3 sec, was exhibited.

# Example 2

A P-type (100) monocrystalline Si substrate having a diameter of 4 inches and a thickness of 500 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm<sup>2</sup>. The porous structure formation rate at this time was 8.4 um/min. and the P-type (100) Si substrate having a thickness of 500 microns as a whole was made porous in 60 minutes.

On the P-type (100) porous Si substrate 21 was grown at low temperature an Si epitaxial layer 22 to a thickness of 0.5 microns by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH4
Radio frequency power:
100 W
Temperature:
800 °C
Pressure:
1 x 10<sup>-2</sup> Torr
Growth rate:

2.5 nm/sec.

Next, on the surface of the epitaxial layer 22 was superposed another Si substrate 23 with an oxidized layer 24 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 700 °C for 0.5 hour, the two SI substrates were bonded firmly together. Then, the porcus SI substrate 1 was chemically stothed away by use of hydrofluoric acid-nitric acid-acetic acid solution (13-35).

As described above, chemical etching rate of ordinary Si monocytatal relative to hydrofluoric acid-mitric acid-acetic acid solution is about a little lower than 1 micron per minute (hydrofluoric acid-mitric acid-acetic acid solution, 13.8), but the chemical etching rate of a porous layer is accelerated by about 100-did thrench. That is, the Si substrate 21 made porous having a thickness of 500 microns was removed in 5 minutes.

Thus, a monocrystalline Si layer having a thickness of 0.5  $\mu$ m could be formed on the SiO<sub>2</sub> layer

Also the thickness of the monocrystalline SI layer obtained was examined by use of Scanning Ellipsometer, Specifically, the whole surface of the 4 inches wafer was scanned for the measurement. As the result, within the plane of the 4 inches water, the difference between the maximum value and the minimum value of the thickness of the monocrystalline SI layer was found to be suppressed 7% or less relative to the minimum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0 x 10<sup>-3</sup> sec. was exhibited

# Example 3

A P-type (100) monocrystalline SI substrate (SI watch lawing a diameter of 3 linches and a thickness of 200 microns was anodized in a 50%. HF soution. The current density at this time was 100 m.Acm. The porous structure formation rate at this time was 10.4 amm/min. and the P-type (100) SI substrate having a blickness of 200 microns as a whole was made prouse in 24 minutes. On the P-type (100) porous SI substrate 21 was grown an SI epitadial layer 22 to a thickness of 0.5 microns by the bias-sputtering method. The deposition conditions are as follows:

RF frequency: 100 MHz Radio frequency powers

800 W Temperature:

Ar gas pressure: 8 x 10<sup>-3</sup> Torr Growth time:

60 minutes
Target direct current bias:

- 200 V Substrate direct current bias: + 5 V.

Next, on the surface of the epitaxial layer 22 was superposed another SI substrate 23 with avoidized layer 24 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two SI substrates were boorded firmly broather. Then the promus SI sub-

surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Then, the porous SI substrate 21 was chemically etched away by use of hydrofluoric add-nitric acid-acetic acid solution (1:3:8).

As described above, chemical etching rate of

ordinary SI monocrystal to hydrollunds activities acid-acelic acid solution is about a little lower than 1 micron per mulut phydrollunds acid-intitie acid-acelic acid solution, 1:38), the chemical etching rate of a porous layer is accelerated by about 100-fold thereof. That is, the SI substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a monocrystalline SI layer having a thickness of 0.5 μm could be formed on the SiO<sub>2</sub> layer 24.

#### Example 4

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mAcm².

The porous structure formation rate at this time was 8.4 Lm/min. and the P-type (100) SI substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous Si substrate 21 was grown an Si epitavial layer 22 to a thickness of 0.5 microns by the liquid phase growth method. The growth conditions are as follows:

Sn Growth temperature: 900 °C Growth atmosphere:

Growth time: 10 minutes.

Solvent:

Next, on the surface of the optizated layer 22 was superposed another 58 substate 23 with an oxidized layer 24 of 5000 angstroms formed on the surface, and by heating in a nitrogen amosphere at 800 °C for 0.5 hour, the wo 51 substrates were bonded firmly logether. Then, the porous 51 substrate 21 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:38). As the result, the 51 substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a monocrystalline Si layer 22 having a thickness of 0.5  $\mu m$  could be formed on the SiO<sub>2</sub> layer 24.

# Example 5

A P-type (100) monocrystalline SI substate having a diameter of 3 inches and a thickness of 200 micross was anodized in a 50% HF solution. The current density at this time was 100 m/km<sup>2</sup>. The procus structure formation rate at this time was 8.4 ammin, and the P-type (100) SI substates having a thickness of 200 micross as a whole was made proxus in 24 minutes. On the P-type (100) porous SI substate 21 was grown an SI epitasidi sieyer 21 to a thickness of 0.5 micross by the low pressure CVD method. The deposition conditions was follower.

Source gas: SiH<sub>4</sub>
Carrier gas: H<sub>2</sub>
Temperature: 850 °C
Pressure: 1 x 10<sup>-2</sup> Torr

Growth rate:

Next, on the surface of the epitavalal layer 22 was superposed another Si substrate with an oxidized layer 24 of 5000 angstroms formed on the surface, and by beating in a introgen atmosphere et 800 °C for 0.5 hour, the two Si substrates were bonded irmly together. Then, the proves Si substrate 21 was chemically eithed away by use of whorfollupion additionally eithed away by use of whorfollupion additional to substrate 21 was chemically eithed away by use of

3.3 nm/sec.

(1:3:8). As the result, the Si substrate 21 made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a monocrystalline SI layer having a thickneed of 0.5 µm could be formed on the SIO<sub>2</sub> layer 28. When SIH<sub>2</sub>O<sub>2</sub> was employed as the source gas, although it was necessary to elevate the growth temperture by some ten degrees, the accelerated otching characteristics inherent in the porous substrate were mainfalled.

# Example 6

On a P-type (100) Si substrate 121 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxiai iayer 122 with a thickness of 1 micron by the CVD method. The dennistion conditions are as follows:

Reactive gas flow rate: SIH<sub>2</sub>Cl<sub>2</sub> 1000 SCCM H<sub>2</sub> 230 /min. Temperature: 1080 °C Pressure: 80 Torr Time:

2 min. The substrate 121 was anodized in a 50% HF solution. The current density at this time was 100 mA/cm2. The porous structure formation rate at this time was 8.4 µm/min, and the P-type (100) Si substrate 121 having a thickness of 200 microns as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate 121 was made porous, and there was no change in the Si epitaxial layer 122. Next, on the surface of the epitaxial layer 122 was superposed another Si substrate 124 with an oxidized layer 125 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour. the two Si substrates were bonded firmly together. Then, the porous Si substrate 123 was chemically etched away by use of hydrofluoric acid-nitric acidacetic acid solution (1:3:8). As the result, the Si substrate 123 made porous having a thickness of

200 microne was removed in 2 minutes.
Also the trickness of the monocrystalline SI
isyer obtained was examined by use of Scanning
Elipsometer. As the result, within the plane of the 3
inches wafer, the difference between the maximum
value end the minimum value of the thickness of
the monocrystalline SI isyer was found to be suppressed SIs or less relative to the maximum value
of the inticiness. As the result of plan in maximum value
of the inticiness. As the result of plan is considered
to the control of the control of the control
sion electron microscopy, the days a transmission electron microscopy, the days
sion electron for the control of the control
sions, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline SI layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline SI layer by use of the microwave reflection method, a high value of 2.0 x 10<sup>-3</sup> sec. was achibited.

# Example 7

On a P-type (100) Si substrate having a diameter of 3 Inches and a thickness of 200 microns was grown an SI epitavial layer 122 to a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH<sub>2</sub>Cl<sub>2</sub> 1000 SCCM H<sub>2</sub> 230 l/min. Temperature: 1080 °C

Pressure: 80 Torr

Time: 1 mln.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 m/kcm². The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) SI substrate 121 having a thickness 200 microres as a whole was made porous in 24 minutes. In this anodization, only the P-type (100) SI substrate was made porous, and there was no change in the SI spixial layer 150.

Next, on the surface of the optizedal layer 122 was superposed another Si substrate 124 with an oxidized layer 125 of 5000 angations formed on the surface, and the heating in a nitrogen atmosphere at 600 °C for 0.5 hour, the two SI substrates were bonded firmly together. Then, the porcus SI substrate 125 was chemically other dawey by use of hydrofluoric acid-nitric acid-acetic acid solution (1.38). As the result, the SI substrate 123 made porous having a thickness of 200 microns was removed in 2 minutes.

As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer 122 to maintain good crystal-linity.

#### Example 8

On a surface of a P-type (100) SI substrate 121 having a diameter of 3 inches and a thickness of 200 microns was formed an N-type SI layer 122 to a thickness of 1 micron by Ion implantation of protons into the surface. The amount of H implanted was found to be 5 x 10<sup>15</sup> (lons/cm²). The substrate 121 was anodized in a 50% HF solution.

The current density at this time was 100 mA/cm<sup>2</sup>. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) Si substrate 121 having a thickness of 200 microns an a whole was made porous in 24 minutes. As described above, in this anodization, only the P-type (100) Si substrate 121 was made porous, and there was no change in the N-type SI layer 122. Next, on the surface of the N-type SI layer 122 was superposed another SI substrate 124 with an oxidized layer 125 of 5000 angstroms formed on the surface, and by heating In a nitrogen atmosphere at 800 °C for 0.5 hour, the two SI substrates were bonded firmly together. Then, the porous Si substrate 123 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 123 made porous having a thickness of 200 microns was removed in 2 min-

As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the SI layer 122 to maintain good crystal-linity.

# Example 9

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm². The porcus structure formation rate at this time was 6.4 um/min and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made provus in 24 minutes.

On the P-type (100) porous SI substrate 11 was grown an SI epitaxial layer 12 to a thickness of 0.5 microns by the MBE (Molecular Beam Epitaxy) method. The deposition conditions are as follows:

Temperature: 700 °C Pressure: 1 x 10<sup>-9</sup> Torr

Growth rate: 0.1 nm/sec. Next, on the surface of the epitaxial layer 12 was superposed another SI substrate 13 with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two SI substrates were bonded firmly together. Subsequently Si<sub>3</sub>N<sub>4</sub> was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 µm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acidacetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si<sub>2</sub>N<sub>4</sub> layer 15, a substrate having a

monocrystalline Si layer having a thickness of 0.5 µm on the SiO<sub>2</sub> layer 14 could be formed.

As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

#### Example 10

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mAcro. The propous structure formation rate at this time was 8.4 m/m/mi. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made norws in 24 migrates.

On the P type (100) porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.5 micron by the plasma CVD method. The deposition conditions are as follows:

Gas: SiH, Radio frequency power: 100 W Temperature: 800 °C Pressure: 1 x 10<sup>-2</sup> Torr Gowth rate:

2.5 nm/sec Next, on the surface of the epitaxial layer 12 vas superposed another Si substrate with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two SI substrates were bonded firmly together. Subsequently, Si<sub>2</sub>N<sub>4</sub> was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 µm. Thereafter, only the silicon nitride film on the porous substrate 11 was removed by reactive ion etching. Then, the porous SI substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acid acetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness Of 200 microns was removed in 2 minutes. After removal of the SisNa layer 15, a substrate having a monocrystalline SI layer 12 having a thickness of 0.5 µm on the SiO2 layer could be formed.

Also the thickness of the monocrystalline SI injury obtained was examined by use of Scanning Elipsometer. As a result, within the plane of the 3 inches wark, the difference between the maximum value and the minimum value of the thickness of the monocrystalline SI layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of observation by defect delineation etching by use of Sirile etching.

the dislocation defect density was found to be suppressed 1 × 10/cm² or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystaline SI layer formation step to maintain good crystallinis. When the life time of minority carriers was measured for the monocrystalline SI layer by use of the MOS Cfmethod, a high value of 2.0 × 10<sup>-3</sup> sec. was exhibited.

# Example 11

10

A P-type (100) monocrystalline SI substrate having a dismeter of 3 inchesses of a blokenses of 5 200 microns was anodised in a 50% HF solution. The current density at this time was 100 mAcm². The porous structure formation rate at this time was 8.4 m/mmin, and the P-type (100) SI substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous SI substrate 11 was grown an SI epitudal siyer IZ to a thickness of 50 micrors by the blass passion was the substrate 11 was grown and SI epitudal siyer IZ to a thickness of 50 micrors by the blass passions.

28 in requency:
100 MHz
Rado frequency power:
600 W
Rado frequency power:
30 September 20
30 Jean pressure:
8 x 10<sup>-9</sup> Torr
Growth time:
80 min.
35 Target direct current bias:
-200 V
Substrate direct current bias:

+ 5 V Next, on the surface of the epitaxial layer 12 was superposed another SI substrate with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si<sub>3</sub>N<sub>4</sub> was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 µm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acidacetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si<sub>2</sub>N<sub>4</sub> layer 15, a substrate having a monocrystalline Si layer 12 having a thickness of 0.5 µm on the SiO2 layer 14 could be formed.

Also, the same effect was obtained when Aplezon Wax was coated in place of the Si<sub>3</sub>N<sub>4</sub> layer, and only the Si substrate made porous could be completely removed.

#### Example 12

A P-type (100) monocrystalline SI substrate having a diameter of 3 nobes and a thickness of 200 microns was anodized in a 50% HF solution. The porcus structure formation rate at this time was 84 aurnium, and the P-type (100) Scubstrate having a thickness of 200 microns as a whole was made porcus in 22 minutes. On the P-type (100) poccus SI substrate 11 was grown an SI epitaxial layer 12 to a thickness of 0.5 microns by the flight phase growth method. The growth conditions are as follows:

Solvent: Sn Growth temperature: 900 °C Growth atmosphere: H<sub>2</sub>

Growth time

Next, on the surface of the epitaxial layer 12 was superposed another Si substrate 13 with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si<sub>3</sub>N<sub>4</sub> was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 µm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acidacetic acid solution (1:3:8). As the result, the Si substrate 11 made porcus having a thickness of 200 microns was removed in 2 minutes. After removal of the SiaN4 layer 15, a substrate having a monocrystalline Si layer 12 having a thickness of 0.5 µm on the SiO2 layer 14 could be formed.

Also, the same effect was obtained when Apiezon Wax was coated in place of the SisNa layer, and only the Si substrate made porcus could be completely removed.

# Example 13

A P-type (100) monocrystaline SI substrate having a dismeter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 m/c/m². The porous structure formation rate at this time was 8.4 m/min, and the P-type (100) SI substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100)

porous Si substrate 11 was grown an Si epitaxial layer 12 to a thickness of 0.5 microns by the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiHe Carrier gas: H<sub>2</sub>

Temperature: 850 °C
Pressure: 1 x 10<sup>-2</sup> Torr
Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 12 was superposed another SI substrate 13 with an oxidized layer 14 of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, Si<sub>3</sub>N<sub>4</sub> was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 µm. Thereafter, only the silicon nitride film 15 on the porous substrate 11 was removed by reactive ion etching. Then, the porous Si substrate 11 was chemically etched away by use of hydrofluoric acid-nitric acidacetic acid solution (1:3:8). As the result, the Si substrate 11 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the SlaN4 layer 15, a substrate having a monocrystalline Si layer having a thickness of 0.5 um on the SiO<sub>2</sub> layer 14 could be formed.

When SiH<sub>2</sub>Cl<sub>2</sub> was employed as the source gas, although it was required to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate could be maintained.

## Example 14

On a P-type (100) SI substrate 111 having a diameter of 3 inches and a thickness of 200 microns was grown an SI epitavidal layer 112 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH<sub>2</sub>Cl<sub>2</sub> 1000 SCCM H<sub>2</sub> 230 Vmin. Temperature: 1080 °C Pressure:

80 Torr

2 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mActim<sup>2</sup>. The porous structure formation rate at this time was 8.4 unrhimi, and the P-type (100) SI substrate 111 thaving a thickness of 200 microns as a whole was made porous in 24 minutes, in this anodization, only the P-type (100) SI substrate 111 was made porous, and there was no change in the SI epitzadi layer 112. Next, on the surface of the epitaxial layer 112 was superposed another SI substrate 114 with an oxidized layer of 5000 angstroms formed on the surface, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently. SixN4 was coated on the bonded substrete by the low pressure CVD method to a thickness of 0.1µm. Thereafter, only the nitride film on the porous substrate was removed by reactive Ion etching. Then, the porous SI substrate 111 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the SI substrate 113 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si<sub>3</sub>N<sub>4</sub> layer 116, a substrate having e monocrystaliine Si layer 112 heving a thickness of 1 µm could be formed on SiO2.

Also the thickness of the monocrystalline SI layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si leyer was found to be suppressed 5% or less reletive to the maximum value of the thickness. As the result of plan view observation of the monocrystalline SI leyer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si leyer formetion process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the microwave reflection method, e high value of 2.0 x 10<sup>-3</sup> sec. was exhibited.

#### Example 15

On e P-type (100) Si substrate 111 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 112 to a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate:
SiH<sub>2</sub>Cl<sub>2</sub> 1000 SCCM
H<sub>2</sub> 230 l/min.
Temperature:
1080 °C
Pressure:
80 Torr
Time:

The substrate was anodized in 6 50% HF solunation. The current density at this time was 100 ma/cm². The porcus structure formation rete at this time was 0.4 mm/min, and the P-type (100) SI substrate 111 having a thickness of 200 microns as a whole was mede porous in 24 minutes. In this anodization, only the P-type (100) Si substrete 111 was made porous, and there was no change in the Si epitaxial layer 112.

Next, on the surface of the epitaxial layer 112 was superposed an Si substrate 114 with an oxidized layer of 5000 angstroms formed on the surface, and by heeting in e nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substretes were bonded firmly together. Subsequently, Si<sub>3</sub>N<sub>4</sub> was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 µm. Thereafter, only the silicon nitride film 116 on the porous . substrate 113 was removed by reactive ion etching. Then, the porous Si substrate 113 was chemically etched eway by use of hydrofluoric acid-nitric acidacetic acid solution (1:3:8). As the result, the Si substrate 113 made porous having e thickness of 200 microns was removed in 2 minutes. After removel of the SiaN4 layer 118, e substrete heving e monocrystalline Si leyer 112 having e thickness of 0.5 µm could be formed on the SiO2 layer 115. As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity. 25

#### Example 16

On e surface of e P type (100) Si substrate 111 having e diameter of 3 inches and a thickness of 200 microns was formed an N-type Si layer 112 to a thickness of 1 micron by Ion implantation of protons into the surface. The amount of H lmplanted was found to be 5 x 1015 (ions/cm2). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm2. The porous structure formation rate at this time wes 8.4 um/min, and the P-type (100) Si substrate 111 having a thickness of 200 microns as e whole wes made porous in 24 minutes. In this anodization, only the P-type (100) Si substrate 111 was made porous, and there was no change in the N-type Si layer 112. Next, on the surface of the N-type Si layer 112 was superposed another SI substrete 114 with an oxidized layer 115 of 5000 angstroms formed on the surfece, and by heeting In a nitrogen etmosphere et 800 °C for 0.5 hour, the Si substretes were bonded firmly together. Subsequently, Sl<sub>3</sub>N<sub>4</sub> was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 um. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive lon etching. Then, the porous Si substrete 113 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic ecid solution (1:3:8). As the result, the SI substrate 113 made porous having e thickness of 200 microns was removed in 2 minutes. After removal of the SlaN4 layer 118, a substrate having a monocrystalline Si layer 112 having a thickness of 1.0 µm could be formed on 1802. As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

# Example 17

A P-type (100) monocrystalline Si substrate having a clameter of 3 Inches and a thickness of 200 microne was anodzed in a 50% HF solution. The current density at this time was 100 m/c/cm². The procus structure formation rate at this time was 8.4 µm/min. and the P-type (100) SI substrate having a thickness of 200 microns as a whole was made procus In 24 minutes.

On the P-type (100) porous SI substrate 31 was grown an SI epitaxial layer 32 to a thickness of 0.5 microns by the MBE (Molecular Beam Epitaxy) method. The deposition conditions are as follows:

Temperature: 700 °C
Pressure: 1 x 10 ° Torr

Growth rete: 0.1 nm/sec.

Next, on the surface of the epitaxial layer 32 wes formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate having an oxide layer 34 or 5000 engstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the both were bonded firmly together. Si<sub>2</sub>N<sub>4</sub> was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 um. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si<sub>3</sub>N<sub>4</sub> layer 35, a substrate having a thin film monocrystalline SI layer 32 could be formed on the SiO2. As the result of cross-sectional observation by transmission electron microscopy, it could be confirmed that no new crystal defect had been introduced in the SI layer to maintain good crystallinity.

# Example 18

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50%. HF solution. The current density at this time was 100 mA/cm². The porcus structure formation rate at this time was 8.4 um/min, and the P-type (100) Si substrate

having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 31 was grown an Si epitaxial layer 32 to a thickness of 5 microns according to the plasma CVD method. The deposition conditions are as follows:

Gas:

Radio frequency power:

100 W Temperature

800 °C Pressure:

1 x 10<sup>-2</sup> Torr Growth rate:

Growth rate: 2.5 nm/sec.

Next, on the surface of the epitaxial layer 32 was formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having an oxide layer 34 of 5000 angstroms formed on the surfece was superposed the above oxide layer 38, and by heeting in a nitrogen atmosphere et 800 °C for 0.5 hour, the both were bonded firmly together. Si<sub>3</sub>N<sub>4</sub> was coated on the bonded sub strete by the low pressure CVD method to a thickness of 0.1 µm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a KOH solution (6 M). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si<sub>3</sub>N<sub>4</sub> layer, a substrate having a monocrystalline Si layer 32 with good crystallinity could be formed on the SiO<sub>2</sub> layer.

Also the thickness of the monocrystalline SI layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline SI layer was found to be suppressed 5% or less reletive to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystelline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline SI layer by use of the MOS C-t method, a high value of 2.0 x 10<sup>-3</sup> sec. was exhibited.

# s Example 19

A P-type (100) monocrystalline Si substrate heving a diameter of 3 inches and e thickness of 200 micro was anodized in a 50% HF solution. The current density at this time was 100 mA/cm2. The porous structure formation rate at this time was 8.4 μm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 31 was grown an Si epitaxial layer 32 to a thickness or 1 micron according to the bias sputtering method. The deposition conditions are

RF frequency: 100 MHz

Radio frequency power

600 W Temperature:

ann ec

Ar gas pressure:

8 x 10-3 Torr Growth time:

120 mln

Target direct current bias:

- 200 V Substrate direct current blas:

+ 5V

Next, on the surface of the epitaxial layer 32 was formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the both were bonded firmly together. SiaNe was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 um. Thereafter, only the nitride film on the porous substrate 31 was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si<sub>2</sub>N<sub>4</sub> layer, a substrate having a monocrystalline Si layer 32 with good crystallinity could be formed on the SiO2 laver.

The same affect was obtained also when Aplezon Wax was coated in place of the Si<sub>2</sub>N<sub>4</sub> layer 35, whereby only the Si substrate 35 made porous could be completely removed.

# Example 20

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm<sup>2</sup>. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) SI substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 31 was grown an Si epitaxiai layer 32 to a thickness of 5 micron by the liquid phase growth method. The growth conditions are as follows:

Solvent Sn

Growth temperature:

900 °C Growth atmosphere:

H<sub>2</sub> 10 Growth time:

10 min

Next, on the surface of the epitaxial layer 32 was formed an oxide layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having an oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 700 °C for 0.5 hour, the both were bonded firmly 20 together. SlaNe was coated on the bonded substrate by the low pressure CVD method to a thickness of 0.1 µm. Thereafter, only the silicon nitride film on the porous substrate was removed by reactive ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a hydrofluoric acid-nitric acid-acetic acid solution (1:3:6). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the SiaNa layer 35, a substrate having a monocrystalline Si layer 32 could be formed on the SiO2. The same effect was obtained also when Apiezon Wax was coated in place of the Si<sub>2</sub>N<sub>4</sub> layer, whereby only the Si substrate made porous could be completely removed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.0 x 10<sup>-3</sup> sec. was exhibited.

# Example 21

A P-type (100) monocrystalline Si substrate having a diameter of 3 Inches and a thickness of 200 microns was anodized in as 50% HF solution. The current density at this time was 100 mA/cm<sup>2</sup>. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) SI substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 31 was grown an Si epitaxial layer 32 to e thickness of 1.0 micron et low temperature by the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH Carrier gas: H Tempereture: 850 °C

1 x 10-2 Torr Pressure: Growth rate 3.3 nm/sec

Next, on the surface of the epitaxial layer 32 was formed an oxidized layer 36 with a thickness of 1000 angstroms. Then, on another Si substrate 33 having on oxide layer 34 of 5000 angstroms formed on the surface was superposed the above oxide layer 36, and by heating in a nitrogen atmosphere at 700 °C for 0.5 hour, the both were bonded firmly together. Si<sub>2</sub>N<sub>4</sub> was coated on the bonded substrete by the low pressure CVD method to a thickness of 0.1 um. Thereafter, only the silicon nitride film 35 on the porous substrate 31 was removed by reactive Ion etching. Then, the porous Si substrate 31 was chemically etched away by use of a hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 31 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si<sub>3</sub>N<sub>4</sub> layer 35, a substrate having e monocrystalline Si leyer 32 could be formed on the SiO2 layer.

When SiH2Cl2 was employed as the source gas, eithough the growth temperature was required to be elevated by some ten degrees, the eccelerated chemical etching characteristics inherent in the porous substrete could be maintained.

On a P-type (100) Si substrete 131 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 132 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive ges flow rate: SiH<sub>2</sub>Cl<sub>2</sub> 1000 SCCM

H<sub>2</sub> 230 Vmin.

Temperature

1080 °C

Pressure 80 Torr

Time:

2 min

The substrete was anodized in a 50% HF solu tion. The current density at this time was 100 mA/cm2. The porous structure formation rate at this time was 8.4 µm/mln. and the P-type (100) Si substrate 131 having a thickness of 200 microns as a whole was made porous in 24 minutes. As described above, only the P-type (100) Si substrate 131 was made porous in this anodization, and there was no change in the Si epitaxial layer 132. Next. on the surface of the epitaxial layer 132 was formed an oxidized layer 137, another SI substrate 134 having an oxidized layer 135 of 5000 angstroms formed on the surface was superposed on the above oxidized layer 137, and the two Si substrates were bonded together firmly by heating at 800 °C for 0.5 hour in a nitrogen atmosphere. By the low pressure CVD method, Si<sub>3</sub>N<sub>4</sub> was coated with a thickness of 0.1 µm on the bonded substrate. Then only the silicon nitride film on the porous substrate was removed by reactive ion etching. Subsequently, the porous Si substrate 133 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrete 133 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the SiaNa layer 136, a substrate having the monocrystalline Si layer 132 having a thickness of 1 µm could be formed on SiO2.

As the result of cross-sectional observetion by trensmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

#### Example 23

On e P-type (100) Si substrate 131 having a diameter of 4 Inches and e thickness of 500 microns was grown an SI epitaxiei layer 132 with a thickness of 0.5 micron by the CVD method. The deposition conditions ere as follows:

Reactive gas flow rate:

SiH<sub>2</sub>Cl<sub>2</sub> 1000 SCCM H<sub>2</sub> 230 l/min.

Temperature

1080 °C Pressure

80 Torr

Time

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm2. The porous structure formation rate at this time was 8.4 um/min. and the P-type (100) Si substrate 131 having a thickness of 500 microns as a whole was made porous. Only the P-type (100) Si substrate 131 was made porous in this anodization, and there was no change in the Si epitaxial layer 132.

Next, on the surface of the epitaxial leyer 132 was formed an oxidized layer 137 with a thickness of 1000 angstroms. Then, another Si substrate 134 having an oxidized layer 135 of 5000 angstroms formed on the surfece was edhered on the above oxidized layer 137, and the both were bonded together firmly by heating et 700 °C for 0.5 hour in a nitrogen atmosphere. By the low pressure CVD method. SixNx was coated with a thickness of 0.1 um on the bonded substrate, and only the silicon nitride film 138 on the porous substrete 133 was removed by reactive ion etching. Then, the porous SI substrate was chemically etched away by use of hydrofluoric acid+nitric acid-acetic acid solution (1:3:8). As the result, the Si substrete mede porous having a thickness of 500 microns was removed in 5 minutes. After removal of the Si<sub>3</sub>N<sub>4</sub> layer 136, a substrate heving the monocrystalline Si lever 132 could be formed on SiO<sub>2</sub>.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 4 inches wafer, the difference between the maximum value end the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 8% or less relative to the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si leyer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si lever by use of the MOS C-t method, a high value of 2.1 x 10<sup>-3</sup> sec. was exhibited.

### Example 24

On the surface of a P-type (100) Si substrate 131 having a diameter of 3 Inches and e thickness of 200 microns was formed N-type Si layer 132 with e thickness of 1 micron by ion implantation of protons. The amount of H implanted was 5 x 1015 (ions/cm²). The substrete was anodized in e 50% HF solution. The current density et this time was 100 mA/cm<sup>2\*</sup> The porous structure formetion rate at this time was 8.4 µm/min, and the P-type (100) Si substrete 131 having e thickness of 200 microns as e whole was mede porous in 24 minutes. Only the P-type (100) Si substrate 131 was made porque in this enodization, and there was no change in the N-type Si layer 132. Next, on the surface of the epitaxial layer 132 was formed an oxidized layer 137 with e thickness of 1000 angstroms. Then, another Si substrate 134 heving an oxidized laver 135 of 5000 angstroms formed on the surfece was edhered on the above oxidized leyer 137, and the two Si substrates were bonded together firmly by

heating at 700 °C for 0.5 hour. By the low pressure CVD method, Si<sub>3</sub>N<sub>4</sub> was coated with a thickness of 0.1 µm on the bonded substrate. Then, only the silicon nitride film on the porous substrate was removed by reactive ion etching, Subsequently, the porous SI substrate 133 was chemically etched ewey by use of hydrofluoric acid-nitric ecid-ecetic acid solution (1:3:8). As the result, the Si substrate made porous heving e thickness of 200 microns was removed in 2 minutes. After removal of the Si<sub>3</sub>N<sub>4</sub> leyer 136, a substrate having the monocrystalline Si layer 132 could be formed on SiO2. As the result of cross-sectional observetion by transmission electron microscopy, it was confirmed that no new crystalline defect had been introduced in the Si layer to maintain good crystallinity.

#### Example 25

- A P-type (100) monocrystalline SI substrete having a dismeter of 3 Inches and a trickness of 200 milrons was anodized in e 50% HF solution. The current density at this time was 100 mA/cm. The porous structure formation rate at this time was 84 u.m.hmin. and the P-type (100) SI substrate hering e thickness of 200 milrons es e whole was mode porous in 24 minutes.
- On the P-type (100) porous Si substrete 41
  was grown an Si epitaxiel layer 42 to e thickness of
  0.5 microns by the MBE (Molecular Beam Epitaxy)
  method. The deposition conditions ere as follows

Temperature: 700 °C
Pressure: 1 x 10<sup>-9</sup> Torr

Growth rate: 0.1 nm/sec.

Next, on the surface of the opitudal layer 42 was formed an oxidated layer 43 with a thickness or 1000 angitumos. Then, another 5 substrate 43 with an oxidized layer 44 of 5000 angstrome formed on the surface was superposed on the particular to the surface was superposed on the particular to the surface was superposed on the particular to the p

Thus, a substrete heving e thin film monocrystalline Si layer 42 could be formed on the po SiO<sub>2</sub>. As the result of cross-sectional observetion by transmission electron microscopy, it was confirmed thet no new crystal defect hed been introduced in the Si layer to maintain good crystallinity.

was removed in 2 minutes.

41 made porous having a thickness of 200 microns

# 5 Example 26

A P-type (100) monocrystalline Si substrete having e diameter of 3 inches and e thickness of 200 microns was anodized in a 50% HF solution.

The current dentity at this time was 100 mAccen<sup>1</sup>,

The procus structure formation rate at this time
was 8.4 ammin, and the P-type (100) St substrate
having a thickness of 200 microns as a whole was
made porcus in 24 minutes. On the P-type (100)
procus SI substrate 41 was grown an SI epitasid
layer 42 to a thickness of 5 microns by the plasma
CVD method. The deposition conditions are as
follows:

Gas:

Radio frequency power:

100 W Temperature:

800 °C Pressure:

Growth rate: 2.5 nm/sec.

Next, on the surface of the optizabil sayer 42 was formed in oxidized layer 45 with a tilchness of 1000 angstroms. Then, another 51 substrate 43 with an oxidized layer 44 of 5000 angstroms formed on the surface was superposed on the above oxidized layer 45, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two 51 substrates were bonded firmly together. Then, the porcus SI substrate 41 was chemically exched away by use of a KOH solution of 6 M.

As described above, ordinary chemical etching rate of SI monocrystal relative to 6M KOH solution is about a title lower than 1 micron per minute, but the chemical etching rate of a porous layer is accelerated by about 100-16d thereof. Then, the SI substate made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a monocrystalline Si layer having good crystallinity could be formed on the SiO<sub>2</sub>.

# Example 27

A P-type (100) monocytealline SI substrate have a diameter of 5 inches and a thickness of a 100 micrors was amond in a 50%. His solution. The current set of the substrate that the was 100 mA/cm. The current structure formation rate at this time was 64 unrhin, and the P-type (100) SI substrate having a thickness of 800 micrors as a whole was made porcus in 70 minutes. On the P-type (100) prous SI substrate 41 was crown an SI epitadal sport 42 to a thickness of 1 micror by the bias-sputtering method. The deposition conditions are as follows:

RF frequency:

100 MHz Radio frequency power:

HACIO W

Temperature:

Ar gas pressure:

8 x 10<sup>-3</sup> Torr Growth time:

120 minutes Target direct current bias:

Substrate direct current bias:

+ 5 V.

Next, on the surface of the optizatial siyer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another 51 substrate 43 with an oxidized layer 44 of 5000 angstrom 5 formed on the surface was superposed on the above oxidized layer 45, and by heating in a rittor-gen strateghere at 800° C for 0.5 hour, the two 51 substrates were bonded firmly pleater. Then, the proposed is substrated to produce the conditional property of the proposed of the property of the property

Thus, a substrate having a monocrystalline Si layer 42 with good crystallinity could be formed on the SiO<sub>2</sub>.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 5 inches water, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 8% or less based on the maximum value of the thickness. As the result of plan view observation of the monocrystalline Si layer by transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystailinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.1 x 10-3 sec, was exhibited.

# Example 28

A P-type (100) monocrystalline SI substrate having a diameter of 3 inches and a thickness of 200 micrors was anodized in a 50% HF soution. The current density at this time was 100 m/cm². The procus structure formation rate at this time was 8.4 am/min. and the P-type (100) SI substrate having a thickness of 200 micrors as a whole was 5 made porous in 24 minutes. On the P-type (100) procus SI substrate 14 was was grown an SI epit total layer 42 to a thickness of 5 micrors by the liquid phase growth enabled. The

are as follows: Solvent:

Sn

Growth temperature: 900 °C

Growth atmosphere:

н Growth time:

10 minutes

Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another SI substrate 43 having an oxidized layer 44 of 5000 angstroms formed on the surface was closely contacted, and by heating in a nitrogen atmosphere at 700 °C for 0.5 hour, the two Si substrates were boned firmly together. Then, the porous Si substrate 41 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 41 made porous having a thickness of 200 microns was removed in 2 min-

utes. Thus, a substrate having a monocrystalline Si layer could be formed on the SiO2.

# Example 29

A P type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm2. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) porous Si substrate 41 was grown an SI epitaxial layer 42 to a thickness of 1.0 mlcrons by to the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH Carrier gas: H<sub>2</sub> 850 °C Temperature: Pressure:

1 x 10<sup>-2</sup> Torr Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 42 was formed an oxidized layer 45 with a thickness of 1000 angstroms. Then, another Si substrate 43 having an oxidized layer 44 of 5000 angstroms on the surface was closely contacted, and by heating in a nitrogen atmosphere at 700 °C for 0.5 hour, the two Si substrates were bonded firmly together. Subsequently, the porous SI substrate 41 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the SI substrate 41 made porous having a thickness of 200 microns was removed in 2 min-

Thus, a substrate having a monocrystalline Si

layer 42 on SiO2 could be formed. When SiH2Ci2 was employed, although it was necessary to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics in-

# herent in the porous substrate was maintained.

# Example 30

On a P-type (100) Si substrate 141 having a diameter of 3 inches and a thickness of 200 microns was grown an Si epitaxial layer 142 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SiH<sub>2</sub>Cl<sub>2</sub> 1000 SCCM H<sub>2</sub> 230 Vmin. Temperature 1080 °C Pressure

80 Torr Time:

2 mln.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm2. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous. Only the P-type (100) Si substrate 141 was made porous in this anodization, and there was no change in the Si epitaxial layer 142. Next, on the surface of the epitaxial layer 142 was superposed another Si substrate 144 having an oxidized layer 145 of 5000 angstroms formed on the surface, and the two Si substrates were bonded together firmly by heating at 800 °C for 0.5 hour in a nitrogen atmosphere. Subsequently, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the SI substrate made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a monocrystalline layer 142 with a thickness of 1 µm on SiO2 could be formed. As the result of cross-sectional observation by a transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the SI layer to maintain good crystallinity.

# Example 31

On a P-type (100) Si substrate 141 having a · diameter of 3 inches and a thickness of 200 microns was grown an SI epitaxiai layer 142 with a thickness of 0.5 mlcron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate: SIH2Cla 1000 SCCM H<sub>2</sub> 230 VmIn.

Tempereture: 1080 °C Pressure: 80 Torr

Time:

The substrate was enodized in a 50% HF solution. The current density et his time was 100 m/bcm². The porous structure formetion rate et this time was 8.4 µm/min. and the P-type (100) Si substrete 141 heving e thickness of 200 microns as a whole was made porous in 24 minutes. Chily the P-type (100) Si substrate 141 was made porous in this anodization, end there was no change in the Si optitudal layer 142.

Next, on the surface of the epitaxial layer 142 was formed an outdized layer 146 with e thickness of 1000 angstroms. Then, another Si substrete heving an oxidized layer 145 of 5000 angstroms formed on the surface was closely contacted, and the two Si substrates were benefit opporter films by heating at 700 °C for 0.5 four. Then, the porous Si substrate was chemically schod ewey by use of hydroflooric acid-nitric acid-acetic acid solution (1:38). As the result, the Si substrate made porous having a thickness of 200 microns was removed in 2 minutes.

Thus, a substrate having a monocrystalline Si layer on SiO<sub>2</sub> could be formed. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

#### Example 32

On the surface of a P-type (100) Si substrate 141 having a diameter of 3 inches and a thickness of 200 microns was formed an N-type Si layer 142 with a thickness of 1 micron by ion implantation of protons. The amount of H implanted was 5 x 1015 (ions/cm2). The substrate was anodized in e 50% HF solution. The current density at this time was 100 mA/cm2. The porous structure formetion rete el this time was 8.4 µn/mln. and the P-type (100) Si substrate having e thickness of 200 microns as e whole was mede porous in 24 minutes. Only the Ptype (100) Si substrete 141 was made porous in this anodization, and there was no change in the Ntype Si leyer 142. Next, on the surface of the epitaxial layer 142 was formed an oxidized layer 148 with e thickness of 1000 angstroms. Then, another Si substrate having an oxidized layer 145 of 5000 angstroms formed on the surface was closely contacted with the above oxidized leyer 148 and the two Si substrates were bonded together firmly by heating at 700 °C for 0.5 hour. Subsequently, the porous Si substrate was chemically etched ewey by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:3). As the result, the Si substrate made porous having e thickness of 200 microns was removed in 2 minutes.

A substrete heving e monocrystalline Si layer on SiO<sub>2</sub> could be formed.

Also the thickness of the monocrystalline Si lever obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches weter, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si leyer was found to be suppressed 5% or less based on the maximum value of the thickness. As the result of plan-view observetion of the monocrystalline Si leyer by e transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline layer by use of the MOS C-t method, a high value of 2.2 x 10<sup>-3</sup> sec. was exhibited.

# Example 33

A P-type (100) monocrystalline SI substrate having a diameter of 3 Inches and a thickness of 200 microns was anodized in e 50%. HF solution. The current density at this time was 100 m/km. The porcus structure formation race at this time was 6.4 m/min. and the P-type (100 SI substrate having a thickness of 200 microns as e whole wes made prous in 24 minutes.

On the P-type (100) porous Si substrete 51 was grown an Si epitaxial leyer 52 to e thickness of 0.5 microns at e low temperature by the MBE method. The deposition conditions are as follows:

Tempereture: 700 °C
Pressure: 1 x 10<sup>-9</sup> Torr
Growth rate: 0.1 nm/sec.

Growth rate: Next, on the surface of the epitaxial layer 52 was superposed e fused silica substrete epplied with optical polishing, and by heeting in e nitrogen atmosphere et 800 °C for 0.5 hour, the two substretes were bonded firmly together. By the low pressure CVD method, SiaN4 was coated on the bonded substrete with a thickness of 0.1 µm. Subsequently, only the nitride film 54 on the porous substrete 51 was removed by reactive ion etching. Then, the porous Si substrete 51 was chemically etched ewey by use of hydrofluoric ecid-nitric ecidecetic ecid solution (1:3:8). As the result, the Si substrate 51 mede porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si<sub>3</sub>N<sub>4</sub> layer 54, a substrate having the monocrystalline Si leyer 52 with e thickness of 0.5 μm on the fused silica 53 could be obtained.

As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystallinity.

# Example 34

A P-type (100) monocrystalline SI substrete having a diameter of 3 Inches and et thickness of 200 microns was anodized in a 50% HF solution. The current density et this time was 100 mAcm<sup>2</sup>. The porous structure formetion rate at this time was 8.4 arm/min, and the P-type (100) a substrete having a thickness of 200 microns as e whole was made porous in 34 minutes. On the P-type (100) porous SI substrete SI was grown an SI epitaxial leyer SC to a thickness of 5 microns by the plasme CVD method. The deposition conditions are as follows:

ollows:
Gas:
SiH4
Radio frequency power:
100 W
Temperature:
800 °C
Pressure:
1 x 10<sup>-2</sup> Torr
Growth rate:
2.5 mm/sec.

Next, on the surface of the epitaxial leyer 52 was superposed a glass substrete having a softening point around 500 °C applied with optical polishing, and by heating in e nitrogen atmosphere at 450 °C for 0.5 hour, the two substrates were bonded firmly together. By the low pressure CVD method, SiaN4 was coated on the bonded substrate with a thickness of 0.1 um. Subsequently, only the nitride film 54 on the porous substrate 51 was removed by reactive lon etching. Then, the porous Si substrate was chemically etched away by use of 6M KOH solution. As the result, the Si substrete made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si<sub>3</sub>N<sub>4</sub> leyer, the monocrystalline layer 52 with a thickness of 5 µm on the low softening glass substrate 53 could be obtained.

# Example 35

A P-type (100) monocrystalline SI substrate having a diameter of 3 Inches and a thickness of 200 microns was anodized in e 50% HF solution. The current density at this time was 100 mAcm<sup>2</sup>. The porous structure formation rete at this time was 6.4 ammin. and the P-type (100) SI substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100)

porous Si substrate 51 was grown an Si epitaxiel tayer to a thickness of 1.0 micron by the bias-sputtering method. The deposition conditions are sellower.

RF frequency:

Radio frequency power:

Temperature: 300 °C

Ar gas pressure: 8 x 10<sup>-3</sup> Torr Growth time:

120 minutes
Target direct current bias:

200 V
 Substrate direct current bias:

+ 5 V. Next, on the surface of the epitaxiel leyer 52 was superposed e glass substrete 53 heving a softening point around 500 °C applied with optical polishing, and by heating in a nitrogen etmosphere at 450 °C for 0.5 hour, the two substrate were bonded firmly together. By the low pressure CVD 25 method, SlaN4 was coated on the bonded substrate with a thickness of 0.1 µm. Subsequently, only the nitride film on the porous substrate was removed by reactive ion etching. Then, the porous SI substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the SI substrate 51 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Sis-Nulayer 54, a substrate having the monocrystalline layer 52 with a thickness of 1.0 um on the low melting point glass could be obtained. The same effect could be also obtained when Apiezon Wax was coated in place of the Si<sub>3</sub>N<sub>4</sub> leyer, and only the SI substrate 51 made porous could be re-

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 3 inches water, the difference between the maximum velue and the minimum value of the thickness of the monocrystalline SI leyer was found to be sup- . pressed 5% or less based on the maximum velue of the thickness. As the result of plan-view observation of the monocrystalline Si leyer by a trensmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less, whereby it could by confirmed that no new crystal defect had been introduced in the monocrystalline SI lever formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high velue of 2.0 x 10<sup>-3</sup> sec, was exhibited.

# Example 38

A P-type (100) monocrystalline SI substrate having a diameter of 3 Inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 m/km². The procus structure formation rate at this time was 8.4 urn/mi. and the P-type (100) SI substrate having a thickness of 200 microns as a whole was made porous in 24 minutes. On the P-type (100) procus SI substrate SI was grown an SI epitaxial layer to a thickness of 10 microns by the fluid phase growth method. The growth conditions are as follows:

Solvent.

Sn

Growth temperature: 900 °C

Growth atmosphere

H<sub>2</sub> Growth time:

20 minutes

Next, on the surface of the epitaxial layer 52 was superposed a glass substrate 53 having a softening point around 800 °C applied with optical polishing, and by heating in a nitrogen atmosphere at 750 °C for 0.5 hour, the two substrates were bonded firmly together. By the low pressure CVD method. Six Na was coated on the bonded substrate with a thickness of 0.1 µm. Subsequently, only the nitride film on the norous substrate was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:8). As the result, the Si substrate 51 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the Si<sub>3</sub>N<sub>4</sub> layer 54, a substrate having the monocrystalline Si layer 52 with a thickness of 10 µm on the glass 53 could be obtained. The same effect could be also obtained when Apiezon Wax was coated in place of

the Si<sub>2</sub>N<sub>4</sub> layer, and only the SI substrate made

porous could be completely removed.

#### Example 37

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a trickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 m/kcm². The porces structure formation rate at this time was 6.4 unmini. and the P-type (100) St substrate having a thickness of 200 microns as a whole was made porcus in 24 minutes. On the P-type (100) procus Si substrate 5 vi was grown at St explained to 100 micros and 100 micros of 100 micros

Source gas: SiH<sub>4</sub> 800 SCCM Carrier gas: H<sub>2</sub> 150 Vmin. Temperature: 850 °C

Pressure: 1 x 10<sup>-2</sup> Torr Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 52 was superposed a fused silica substrate 53 applied with optical polishing, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two Si substrates were bonded firmly together.

By the low pressure CVD method, Sish. was coaled on the bonded substrate with a thickness of 0.1 km. Subsequently, only the nitride film on the procus substrate was removed by reactive lon exciting. Then, the procus SI substrate 51 was chemically extend away by use of hybrodiloxic acid-nitric solid-acides acid solution. As the result, the SI substrate 51 made procus having a thickness of 200 milliones was removed in 2 minutes. After removal of the SIA, buyer, a substrate having the monocrystallian SI layer SZ with a thickness of

the monocrystalline SI layer 52 with a thickness of 1.0 μm on the fused silica substrate 53 could be formed.

When SiH<sub>2</sub>Cl<sub>2</sub> as the source gas was em-

When SiH<sub>2</sub>Cl<sub>2</sub> as the source gas was employed, although it was necessary to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate were maintained.

#### Example 38

On a P-type (100) SI substrate 151 having a diameter of 4 inches and a thickness of 300 microns was grown an Si epitaxial layer 152 with a thickness of 1 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate:

SiH<sub>2</sub>Cl<sub>2</sub> 1000 SCCM H<sub>2</sub> 230 Vmln.

Temperature:

1080 °C

80 Torr

Time:

2 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100
mAcm. The prorus structure formation rate at this
time was 8.4 unminn. and the P-type (100) SI
substrata 151 shaving a thickness of 300 microns as
a whole was made porous in 38 minutes. As described above, only the P-type (100) SI substrate
151 was made porous in this anodization, and there
was no change in this Si epitacial layer 152. Was
con the surface of the epitaxial layer 152 was superposed a fused silics substrate 154 applied with
optical polishing, and the two substrate were boneded together farmly by healing a 600 °C to 75.

hour in a nitrogen atmosphere. By the low pressure CVD method, SN, was deposited with a tildenses of 0.1 tum to be coated on the bonded substrate. Subsequently the nitride film 155 on the porous substrate 153 was removed by reactive lon etching. Then, the prorus SI substrate was chemically etched away by use of hydrofilluoric acid-nitric acid-acitic acid subtino (1:38). As the result, the SI substrate 153 made porous having a thickness of 300 microns was removed in 4 minutes. After removal of the SIN, layer 155, a substrate having the monocrystalline SI layer 155 having a thickness of 1 tum on the fused silics substrate 154 could be formed.

As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the SI layer to maintain good crystallinity.

#### Example 39

On a P-type (100) Si substrate 151 having a diameter of 3 inches and a thickness of 200 microns was grown an SI epitaxial layer 152 with a thickness of 0.5 micron by the CVD method. The deposition conditions are as follows:

Reactive gas flow rate:
SiH<sub>2</sub>Cl<sub>2</sub> 1000 SCCM
H<sub>2</sub> 230 l/mln.
Temperature:
1080 °C
Pressure:
80 Torr
Time:

1 min.

The substrate was anodized in a 50% HF solution. The current density at this time was 100 m m/cm². The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) SI substrate 151 heimig a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate was made porous in this anodization, and there was no change in the SI coliziolal laver 150.

Next, on the surface of the epitadal layer 152 was superposed a fused silics substrate 154 applied with optical pollating, and the two substrates were bonded topether firmly by heading at 80 °C for 0.5 hour. By the low pressure CVD method, SIN, was deposited with a thickness of 0.1 in to be coated on the bonded substrate. Subsequently the nitride film 155 on the prorus substrate 155 was removed by reactive ion etching. Then, the porous SI substrate was chemically etched away by use of hydrofitoric acid-nitric acid-acids acid-nitric acid-acids acid-nitric acid-acids acid solution (1:23). As the result, the SI substrates 153 made porous having a thickness of 200 microns was removed in 2 minutes. After removal of the

Si<sub>3</sub>N<sub>4</sub> layer 155, a substrate having the monocrystalline SI layer 152 having a thickness of 0.5 I'm on the bused silica 154 could be formed. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the SI layer to mainfain good crystallinity.

#### Example 4

On the surface of a P-type (100) Si substrate 151 having a diameter of 4 Inches and a thickness of 300 microns was formed an N-type Si layer 152 with a thickness of 1 micron by ion implantation of protons. The amount of H+ Implanted was 5 x 1015 (lons/cm²). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm2. The porous structure formation rate at this time was 8.4 µm/mln. and the P-type (100) Si substrate 151 having a thickness of 300 microns as a whole was made porous in 37 minutes. Only the P type (100) Si substrate was made porous in this anodization, and there was no change in the N-type Si layer 152. Next, on the surface of the N type Si layer 152 was superposed a fused silica substrate 154 with optical polishing. and the two substrates were bonded together firmly by heating at 800 °C for 0.5 hour in a nitrogen atmosphere. By the low pressure CVD method, Si<sub>3</sub>N<sub>4</sub> was deposited to a thickness of 0.1 µm to he crated on the bonded substrate. Subsequently, only the nitride film 155 on the porous substate 153 was removed by reactive ion etching. Then, the porous Si substrate was chemically etched away by use of hydrofluoric acid-nltric acid-acetic acid solution. As the result, the Si substrate 151 made porous having a thickness of 300 microns was removed in 4 minutes. After removal of the Si<sub>3</sub>N<sub>4</sub> layer 155, a substrate having the monocrystalline SI layer 152 with a thickness of 1.0 μm on the fused silica 154 could be formed.

Also the thickness of the monocrystalline SI layer obtained was examined by use of scanning Ellipsometer. As the result, within the plane of the 4 Inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 6% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si layer by use of the MOS C-t method, a high value of 2.2 x 10<sup>-3</sup> sec. was exhibited.

Shortly speaking, according to the present invention, in obtaining an Si crystalline layer accellent in crystallinety equal to monocrystalline Si wefer also on a light-transparent insulation material substrate represented by glass, a process for forming a semiconductor substrate excellent in aspects of productivity, uniformity, controllability, economy can be provided. Further, according to the present invention, there can be provided a process for forming a semiconductor substrate broad in scope of application which can make avail of the advantages of the SOI device of the prior.

# Example 41

A P-type (100) monocrystalline SI substrate howing e diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm². The porous structure formation rate at this time was 8.4 urn/min. and the P-type (100) SI substrate having a thickness of 200 microns as a whole was made porous in 24 minutes.

On the P-type (100) porous SI substrate 61 was grown an SI apitaxial layer 62 to a thickness of 0.5 microns by the MBE method. The deposition conditions are as follows:

Temperetures:

700 °C
Pressure:
1 x 10<sup>-9</sup> Torr
Growth rate:
0.1 nm/sec.

Next, on the surface of the epitaxial layer 62 was superposed a fused silica substrate 63 applied with optical polishing, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was, chemicelly etched awey by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 61 made porous having a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystelline SI layer 62 with e thickness of 0.5 µm on the fused sliica 63 could be obtained. As the result of cross-sectional observation by transmission electron microscopy, it was confirmed that no new crystal defect had been introduced in the Si layer to maintain good crystellinity.

#### Example 42

A P-type (100) monocrystalline Si substrate having a diameter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mA/cm². The porous structure formetion rate at this time

was 8.4 µm/min. and the P-type (100) Si substrate having a thickness of 200 microns as a whole was made porous in 21 minute. On the P-type (100) porous SI substrate 61 was grown an SI epitaxlel layer 62 to a thickness of 5 microns by the plasme CVD method. The deposition conditions are as

follows: Gas:

SIH<sub>4</sub> Radio frequency power: 100 W

Temperature:

Pressure: 1 x 10<sup>-2</sup> Torr

1 x 10<sup>-2</sup> Torr Growth rate: 2.5 nm/sec.

Next, on the surface of the epitzadia leyer 62 was superposed aglass substrate having a sottening point around 500 °C applied with optical polishing, and by heating in a nitrogen embosphere at 450 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was chemically etched away by use of 6M KOH solution. As the result, the Si substrate 61 made portious heiving a thickness Of 200 microns was removed in 2 minutes. A substrate heiving the mon-curystalline SI layer 62 with a thickness of 5 Lm on the low softening point glass 63 could be obtained.

# Example 43

20

A P-type (100) monocrystalline SI substrate having a camera of 3 inches and a thismost of 35 of 30 omicrors was anodized in a 50% HF selution. The current density at this time was 100 molecular. The popular structure formetion rate at this time was 8.4 aurinni, and the P-type (100) Si substrate was 8.4 aurinni, and the P-type (100) Si substrate 40 wing a thickness of 200 micrors as a whole was 40 molecular size of 500 micrors as a whole was 40 molecular size of 500 micrors and Si opilization of 500 micrors and 500 micrors as a whole was 40 molecular size of 300 micrors and 500 micror

RF frequency:

100 MHz Redio frequency power:

600 W Temperature:

300 °C Ar gas pressure: 8 x 10<sup>-3</sup> Torr

Growth time: 120 minutes Target direct current bias:

- 200 V

Substrate direct current bias:

+ 5 \

Next, on the surface of the epitaxial layer 62 was superposed a glass sustrate 63 having a softening point around 500 °C applied with optical polishing, and by heating in a intropen atmosphere at 450 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si usubstrate 61 was chemically etched away by use of 7 M NGCH solidion.

As described above, the chemical eiching rate of ordinary Si monocrystal relative to 7 M NaOH solution is about a little less than 1 micron per minute, but the chemical eiching rate of the porous layer is accelerated by about 100-fold thereof. That is, the SI substrate 61 made prous having a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline SI layer 62 with a thickness of 1.0 µm on the low melting point glass 83 could be formed.

Also the thickness of the monocrystalline Si layer obtained was examined by use of Scanning Filinsometer. As the result, within the plane of the 3 inches wafer, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si layer was found to be suppressed 5% or less based on the maximum value of the thickness. As the result of plan-view observation of the monocrystalline Si layer by a transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less, whereby it could be confirmed that no new crystal defect had been introduced in the monocrystalline Si layer formation step to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline layer by use of the MOS C-t method, a high value of 2.1 x 10<sup>-3</sup> sec. was exhibited.

#### Example 44

A P-type (100) monocrystalline SI substrate having a diameter of 3 Inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 mAcm<sup>2</sup>. The provus structure formation rate at this time was 8.4 arm/min and the P-type (100) SI substrate having a thickness of 200 microns as a whole was made prorus in 24 minutes. On the P-type (100) procus SI substrate 61 was grown an SI epitaxial juspe 82 to a thickness of 10 microns by the liquid phase growth method. The growth conditions are as follows:

tollows: Solvent: Sn Growth temperature: 900 °C Growth atmosphere: H<sub>2</sub> Growth time: 20 minutes.

Next, on the surface of the optizabil layer 62 was superposed a glass substrate 63 having a softening point around 800 °C applied with optical polishing, and by heating in a intergon atmosphere at 750 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous 51 substrate 61 was chemically eithed away by use of hydrollucine acid-trible caid-scaled acid solution. As the result, the 61 substrate 61 made porous having a thickness of 200 microus was removed in 2 a thickness of 200 microus was removed in 2 substrate having the monocytopismic 91 could be abilitated having the monocytopismic 91 could be abilitated.

#### Example 45

A P-type (100) monocrystalline SI substrate having a dismeter of 3 inches and a thickness of 200 microns was anodized in a 50% HF solution. The current density at this time was 100 m/d/m². The prosus structure formation rate at this time was 8.4 um/m²n, and the P-type (100) SI substrate having a thickness of 120 microns as a whole was made prous in 24 minutes. On the P-type (100) potus SI substrate 61 was grown an SI spitaxial isyer to a thickness of 1.0 micron by the low pressure CVD method. The deposition conditions are as follows:

Source gas: SiH<sub>4</sub> 800 SCCM
Carrier gas: H<sub>2</sub> 150 l/min.
Temperature: 850 °C
I x 10<sup>-2</sup> Torr
Growth rate: 3.3 nm/sec.

Next, on the surface of the epitaxial layer 62 was superposed a fused silica substrate 63 applied with optical polishing, and by heating in a nitrogen atmosphere at 800 °C for 0.5 hour, the two substrates were bonded firmly together. Then, the porous Si substrate 61 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution. As the result, the Si substrate 61 made porous having a thickness of 200 microns was removed in 2 minutes. A substrate having the monocrystalline SI layer 62 with a thickness of 1.0 µm on the fused silica 63 could be formed. When SiH2Ci2 as the source gas was employed, aithough it was necessary to elevate the growth temperature by some ten degrees, the accelerated chemical etching characteristics inherent in the porous substrate were maintained.

# Example 46

On a P-type (100) Si substrate 161 having a diameter of 4 inches and thickness of 300 microns was grown an Si epitaxial layer 162 with a thickness of 1 micron by the CVD method. The depositions are as follows: ve gas flow rate: 2 100 SCCM 1 Vmin. rature: C

R1

ubstrate was anodized in a 50% HF solucurrent density at this time was 100 The porous structure formation rate at this 8.4 µm/min, and the P-type (100) Si 161 having a thickness of 300 microns as as made porous in 37 minutes. Only the 00) SI substrate 161 was made porous in ization, and there was no change in the Si layer 162. Next, on the surface of the layer was superposed an optical polished ca glass substrate 164 and the two subare bonded together firmly by heating at for 0.5 hour in a nitrogen atmosphere. , norous Si substrate 163 was chemically ay by use of hydrofluoric acid nitric acidd solution (1:3:6). As the result, the Si 163 made porous having a thickness of ons was removed in 4 minutes. A subing the monocrystalline SI layer 162 hav-

kness of 1 µm on the fused silica glass

164 could be formed

the thickness of the monocrystalline Si ⇒ned was examined by use of Scanning ter. As the result, within the plane of the 4 fer, the difference between the maximum the minimum value of the thickness of crystalline Si layer was found to be sup-7% or less based on the maximum value kness. As the result of plan-view observao monocrystalline Si layer by a transmisiron microscopy, the dislocation defect as found to be suppressed 1 x 103/cm2 or reby it could be confirmed that no new afect had been introduced in the mone Si laver formation process to maintain stallinity. When the life time of minority as measured for the monocrystalline SI use of the MOS C-t method a high value 0<sup>-3</sup> sec. was exhibited

#### 47

ve gas flow rate:

P-type (100) Si substrate 161 having a of 3 inches and a thickness of 200 as grown an Si epitaxial layer 162 with a of 0.5 micron by the CVD method. The conditions are as follows:

Temperature 1080 °C Pressure: 80 Torr Time: 1 mln.

H<sub>2</sub> 230 l/mln.

SIH<sub>2</sub>Cl<sub>2</sub> 1000 SCCM

The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm². The porous structure formation rate at this time was 8.4 µm/min. and the Ptype (100) SI substrate 181 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the Ptype (100) SI austrate 161 was made porous in this anodization, and there was no change in the SI colized layer el.

Next, on the surface of the epitaxial layer 182 was superposed an optical polished based alice glass substrate 164 and the two outstanding were bonded together firmly by heading at 800 °C to 75. hour. Then, the porous SI substrate 153 was chemically eithed away by use of hydroflutoric acid-nific acid-acetic acid solution. As the result, the SI substrate made procus having a thickness of 0.5 am on the glass substrate could be formed. As the result of cross-scienced observations of 0.5 am on the glass substrate could be formed. As the result of cross-scienced observation of the control of the country of the country

#### Example 48

On the surface of a P-type (100) Si substrate 161 having a diameter of 3 Inches and a thickness of 200 microns was formed an N-type Si layer 162 with a thickness of 1 micron by ion implantation of protons. The amount of H mplanted was 5 x 1015 (ions/cm²). The substrate was anodized in a 50% HF solution. The current density at this time was 100 mA/cm2. The porous structure formation rate at this time was 8.4 µm/min. and the P-type (100) Si substrate 161 having a thickness of 200 microns as a whole was made porous in 24 minutes. Only the P-type (100) Si substrate 161 was made porous in this anodization, and there was no change in the Ntype SI layer 162. Next, on the surface of the epitaxial layer 162 was superposed an optical pol-Ished fused silica glass substrate 164 and the two substrates were bonded together firmly by heating at 800 °C for 0.5 hour. Then, the porous Si substrate 163 was chemically etched away by use of hydrofluoric acid-nitric acid-acetic acid solution (1:3:6). As the result, the SI substrate 163 made porous having a thickness of 200 microns was removed in 4 minutes. A monocrystalline Si iayer 162 with a thickness of 1.0 μm on the glass substrate 164 could be formed. As the result of crosssectional observetion by transmission electron miscroscopy, it was confirmed that no new crystal defect had been introduced in the Si leyer to maintain good crystallinity.

#### Example 49

A P-type (100) monocrystalline SI substrate having a dameter of 6 inches and e thickness of 800 microns was anodized in e 50 % HF solution. The current density at this time was 10 m.Acm². In 10 minutes, e porcus layer having a thickness of 20 microns was formed on the surface. On the P-type (100) prorus SI substrate was grown an SI epitaxial layer to a thickness of 0.5 micron by the low pressure CVD method. The deposition conditions are as follows:

Gas: SiH<sub>2</sub>Cl<sub>2</sub> (0.6 Vmin), H<sub>2</sub> (100 Vmin.)

Vmin.)
Tempereture: 850 °C

Pressure: 50 Torr Growth rete: 0.1 µm/min.

Next, the surface of the epitaxial layer was thermally oxidized to 50 nm. On the thus obtained thermally oxidized film was superposed another sition substrate having an oxidized layer of 0.8 micron on the surface, and by heeting in a nitrogen atmosphere at 900 °C for 1.5 hours, the two substrates were firmly bonded togother.

Thereefter, grinding of 585 microns was applied from the back side of the silicon substrate to have the porous layer exposed.

By the plasma CVD method, Sis N. was depossited to a thickness of 0.1 µm to be coated on the bonded substrate. Subsequently, only the silicon nitride film on the porous substrate was removed by reactive ion etching.

Than, the bonded substrate was subjected to chemically selective etching by use of a hydrofluoric ecid-nitric acid-seetic ecid solution. After 15 minutes, the porous SI layer was chemically selectively etched to be completely removed, and only the monocrystalline SI layer as the etch-stop meetrial remained without being chemically arched.

The chemical etching rele of non-porous SI monocrystalline relative to the electant is very low es ebout 40 angstroms even after 15 minutes, whereby the selective relic of the etching race between the non-porous leyer is very large and the etched amount in the non-porous SI layer was practically negligible. Allow the properties of the

The same effect was also obtained, when Apiezon Wax or Electron Wax was coated in place of the Si<sub>2</sub>N<sub>6</sub>, and only the Si leyer made porous could be completely removed.

Also, the thickness of the monocrystalline SI layer obtained was examined by use of Scanning Ellipsometer. As the result, within the plane of the 6 inches water, the difference between the maximum value and the minimum value of the thickness of the monocrystalline Si leyer was found to be suppressed 10% or less based on the maximum value of the thickness. As the result of plan view observetion of the monocrystalline layer by e transmission electron microscopy, the dislocation defect density was found to be suppressed 1 x 103/cm2 or less, whereby it could be confirmed that no new crystel defect had been introduced in the monocrystalline Si layer formation process to maintain good crystallinity. When the life time of minority carriers was measured for the monocrystalline Si leyer by using the MOS C-t method, a high value of 2.0 x 10<sup>-3</sup> sec. was exhibited.

A process for preparing e semiconductor member comprises the steps of:

forming e member having a non-porous monocrystalline semiconductor region on e porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance o onto the surface of the non-porous monocrystalline semiconductor region, and then

removing the porous monocrystalline semiconductor region by etching.

# Cleims

- A process for preparing e semiconductor member comprising the steps of:
- forming e member having e non-porous monocrystalline semiconductor region on e porous monocrystalline semiconductor region.
- bonding the surface of e member of which the surface is constituted of an insuleting substance onto the surface of said non-porous monocrystalline semiconductor region, end than
  - removing said porous monocrystalline semiconductor region by etching.
- A process for preparing a semiconductor member according to Claim 1, wherein said monocrystalline semiconductor comprises silicon.
- A process for preparing a semiconductor member according to Claim 1, wherein said porous monocrystalline semiconductor region is P-type.

- A process for preparing a semiconductor member occording to Claim 1, wherein said non-porous monocrystalline semiconductor recolon has a thickness of 50 microns or less.
- A process for preparing e semiconductor member according to Claim 1, wherein said bonding step is carried out in an etmosphere containing nitrogen.
- A process for preparing a semiconductor member according to Claim 1, wherein said bonding step includes e heat treatment in an etmosphere containing nitrogen.
- A process for preparing e semiconductor member eccording to Claim 1, wherein said non-porous monocrystalline semiconductor region is formed by epitaxial growth.
- 8. A process for preparing a semiconductor member according to Calim 1, wherein said nonporous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitualsi method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the cuid phase growth method or the bias-sputtering method.
- A process for preparing e semiconductor member according to Claim 1, wherein said porous monocrystalline semiconductor region is obtained by making the nonporous semiconductor monocrystalline region porous by anodization.
- A process for preparing e semiconductor member according to Claim 9, wherein said anodization is carried out in an HF solution.
- A process for preparing e semiconductor member according to Claim 2, wherein said non-porous monocrystalline semiconductor region is intrinsic or N-type.
- A process for preparing e semiconductor member eccording to Claim 11, wherein sald N-type silicon is formed by proton irradiction or opitaxial growth.
- 13. A process for preparing e semiconductor member according to Claim 1, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.
- 14. A process for preparing a semiconductor

- member according to Claim 1, wherein the member of which the surface is constituted of an insulating substance is e silicon substrate with its surface being oxidized.
- 15. A process for preparing a semiconductor member according to Claim 1, wherein etching of said porous monocystaline semiconductor region is carried out under the state where the members bonded to each other are covered with an anti-etching material.
  - A process for preparing a semiconductor member according to Claim 15, wherein said anti-etching material is silicon nitride.
  - A process for preparing a semiconductor member according to Claim 15, wherein sald anti-etching material is Apiezon Wax.
  - 18. A process for preparing a semiconductor member comprising the steps of:

forming a member having e non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region,

- forming a region constituted of an Insulating substance on the non-porcus moncorystaline semiconductor side of said member, then bonding the surface of e member of which the surface is constituted of an Insulating substance onto the surface of the region con-
- stituted of said insuleting substance, and removing said porous monocrystalline semiconductor region by etching.
- A process for preparing e semiconductor member according to Claim 18, wherein sald monocrystalline semiconductor comprises silicon.
- A process for preparing a semiconductor member according to Claim 18, wherein said porous monocrystalline semiconductor region is P-type.
  - A process for preparing a semiconductor member according to Claim 18, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.
  - A process for preparing e semiconductor member according to Claim 18, wherein said bonding step is carried out in an etmosphere containing nitrogen.
  - 23. A process for preparing a semiconductor member according to Claim 18, wherein said bonding step includes e heat treatment in an

atmosphere containing nitrogen.

- 24. A process for preparing a semiconductor member according to Claim 18, wherein said non-porous monocrystalline semiconductor region is formed by epitaxial growth.
- 28. A process for preparing a semiconductor member according to Elaim Ris, wherein said non-porous monocrystalline semiconductor region is tormed according to the method selected from the molecular beam epitacial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the jud phase growth method or the blas-sputtering method.
- 26. A process for preparing a semiconductor member according to Claim 18, wherein said porous monocrystalline semiconductor region is obtained by making the non-porous semiconductor monocrystalline region porous by anodization.
- A process for preparing a semiconductor member according to Claim 18, wherein said anodization is carried out in an HF solution.
- A process for preparing a semiconductor member according to Claim 19, wherein said non-porous monocrystalline semiconductor region is intrinsic or N-type.
- A process for preparing a semiconductor member according to Claim 28, wherein said N-type silicon is formed by proton Irradiation or epitaxial growth.
- 30. A process for preparing a semiconductor member according to Claim 18, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.
- 31. A process for preparing a semiconductor member according to Cialm 18, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.
- 32. A process for preparing a semiconductor member according to Claim 18, wherein eithing of said porous monocrystalline semiconductor region is carried out under the state where the members bonded to each other are covered with an anti-ething material.
- 33. A process for preparing a semiconductor

- member according to Claim 32, wherein said anti-etching material is silicon nitride.
- A process for preparing a semiconductor member according to Claim 32, wherein said anti-etching material is Apiezon Wax.
- 35. A process for preparing a semiconductor member comprising the steps of:
  - making a non-porous monocrystalline semiconductor member porous to form a porous monocrystalline semiconductor region,
  - forming a non-porous monocrystalline semiconductor region on said porous monocrystalline semiconductor region, bonding the surface of a member of which
  - the surface is constituted of an insulating substance onto the surface of said non-porous monocrystalline semiconductor region, and removing said porous monocrystalline
- removing said porous monocrystalline semiconductor region by etching.
- A process for preparing a semiconductor member according to Claim 35, wherein said monocrystaliine semiconductor comprises silicon.
- A process for preparing a semiconductor member according to Claim 35, wherein said porous monocrystalline semiconductor region is P-type.
- 38. A process for preparing a semiconductor member according to Claim 35, wherein said non-porous monocrystalline semiconductor recion has a thickness of 50 microns or less.
- A process for preparing a semiconductor member according to Claim 35, wherein said bonding step is carried out in an atmosphere containing nitrogen.
- 40. A process for preparing a semiconductor member according to Claim 35, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.
- 41. A process for preparing a semiconductor member according to Claim 35, wherein said non-porous monocrystalline semiconductor recion is formed by epitaxial growth.
- 42. A process for preparing a semiconductor member according to Claim 38, wherein said non-prous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure

CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.

- 43. A process for preparing e semiconductor member according to Claim 35, wherein said porous monocrystalline semiconductor region Is obtained by anodization.
- 44. A process for preparing a semiconductor member according to Claim 43, wherein said anodization is carried out in an HF solution.
- 45. A porous for preparing a semiconductor member eccording to Claim 38, wherein said nonporous monocrystalline semiconductor region Is intrinsic or N-type.
- 46. A process for preparing a semiconductor member according to Claim 45, wherein said N-type silicon is formed by epitaxial growth
- 47. A process for preparing a semiconductor member according to Claim 35, wherein the member of which the surface is constituted of en insulating substance comprises e light-trensmissive material.
- 48. A process for preparing e semiconductor member according to Claim 35, wherein the member of which the surface is constituted of en insuleting substance is a silicon substrete with its surface being oxidized.
- member comprising the steps of:

meking a non-porous monocrystalline semiconductor member porous to form e porous monocrystalline semiconductor region,

forming e non-porous monocrystalline semiconductor region on sald porous monocrystalline semiconductor region.

forming region constituted of an Insulating substance on said non-porous monocrystalline semiconductor region side,

bonding the surface of e member of which the surface is constituted of an insulating substance onto the surface of said region constituted of the insuleting substance, and

- removing said porous monocrystalline semiconductor region by etching.
- 50. A process for preparing e semiconductor member according to Claim 49, wherein said monocrystalline semiconductor comprises sill-
- 51. A process for preparing e semiconductor

- member according to Claim 49, wherein said porous monocrystalline semiconductor region is P-type.
- 5 52. A process for preparing e semiconductor member according to Claim 49, wherein said non-parous monocrystalline semiconductor region has a thickness of 50 microns or less.
- 10 53. A process for preparing a semiconductor member according to Claim 49, wherein said bonding step is carried out in an atmosphere containing nitrogen.
- 15 54. A process for preparing a semiconductor member according to Claim 49, wherein said bonding step includes e heet treetment in an atmosphere containing nitrogen.
- 55. A process for preparing a semiconductor member according to Claim 49, wherein said non-porous monocrystalline semiconductor region is formed by epitaxial growth.
- 56. A process for preparing a semiconductor member according to Claim 49, wherein said non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-sputtering method.
- 49. A process for preparing a semiconductor 35 57. A process for preparing e semiconductor member according to claim 49, wherein said porous monocrystalline semiconductor region is obtained by anodization.
  - 58. A process for preparing a semiconductor member according to Claim 57, wherein said anodization is carried out in an HF solution.
  - 59. A process for preparing a semiconductor member according to Claim 50, wherein said non-porous monocrystalline semiconductor region is intrinsic or N-type.
  - 60. A process for preparing a semiconductor member eccording to Ciaim 59, wherein said N-type silicon is formed by epitaxial growth.
  - 61. A process for preparing a semiconductor member according to Claim 49, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.

- 62. A process for preparing a semiconductor member according to Claim 49, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.
- 63. A process for preparing a semiconductor member comprising the steps of:

making a first non-porous monocrystalline semiconductor member partially porous to form a porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region,

forming a third non-porous monocrystalline semiconductor region on said porous monocrystalline semiconductor region,

bonding the surface of a member of which the surface is constituted of an insulating substance onto the surface of said third non-porous monocrystalline semiconductor region, and

removing said second non-porous monocrystalline semiconductor region by mechanical pollshing, and removing laid porous monocrystalline semiconductor region by etching.

- 64. A process for preparing e semiconductor member according to Claim 63, wherein said monocrystalline semiconductor comprise silicon
- 65. A process for preparing a semiconductor member according to Claim 63, wherein said porous monocrystalline semiconductor region is P-type.
- 66. A process for preparing a semiconductor member according to Claim 63, wherein said third non-porous monocrystalline semiconductor region has a thickness of 50 microns or less
- 67. A process for preparing a semiconductor member according to Claim 63, wherein said bonding step in carried out in an atmosphere containing nitrogen.
- 68. A process for preparing a semiconductor member according to Claim 63, wherein sald bonding step Includes a heat treatment in an atmosphere containing nitrogen.
- 69. A process for preparing a semiconductor member according to Cleim 63, wherein said third non-porous monocrystalline semiconductor region is formed by epitaxiel growth.
- 70. A process for prepering a semiconductor

- member according to Claim 83, wherein said third non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitizalia method, the plasme CVD method, the low pressure CVD method, the photo CVD method, the liquid phase growth method or the bias-
- 71. A process for preparing a semiconductor member according to Claim 63, wherein said porous monocrystalline semiconductor region is obtained by anodization.

souttering method.

- 72. A process for preparing e semiconductor member eccording to Claim 71, wherein said anodization is carried out in an HF solution.
  - 73. A process for preparing a semiconductor member according to Claim 64, wherein said third non-porous monocrystalline semiconductor region is intrinsic or N-type.
  - A process for preparing a semiconductor member according to Claim 73, wherein said N-type sillcon is formed by epitaxial growth.
  - 75. A process for preparing a semiconductor member according to Claim 63, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.
  - 76. A process for preparing a semiconductor member according to Claim 63, wherein the member of which the surface is constituted of an Insulating substance is a silicon substrate with its surface being oxidized.
  - 77. A process for preparing a semiconductor member comprising the steps of:
    - making a first non-porous monocrystalline semiconductor member partially porous to form e porous monocrystalline semiconductor region and a second non-porous monocrystalline semiconductor region.
      - forming a third non-porous monocrystalline semiconductor region on said porous monocrystalline semiconductor region,
    - forming a region constituted of an insuleting substance on said third non-porous monocrystalline semiconductor region side,
    - bonding the surface or e member of which the surface is constituted of en insulating substance onto the surface of said region constituted of the insuleting substance, and
      - removing said second non-porous monocrystalline semiconductor by mechanical

- polishing, end removing said porous monocrystalline semiconductor region by etching.
- A process for prepering e semiconductor member according to Claim 77, wherein said monocrystalline semiconductor comprises silicon
- A process for preparing e semiconductor member according to Claim 77, wherein said porous monocrystalline semiconductor region is P-type.
- 80. A process for preparing a semiconductor member according to Claim 77, wherein said third non porous monocrystalline semiconductor region has e thickness of 50 microns or less.
- 81. A process for preparing a semiconductor member according to Claim 77, wherein said bonding step is carried out in an atmosphere containing nitrogen.
- 82. A process for preparing a semiconductor member according to Claim 77, wherein said bonding step included e heet treatment in an atmosphere containing nitrogen.
- 83. A process for preparing a semiconductor member according to Claim 77, wherein laid third non-porous monocrystalline semiconductor region is formed by epitaxiel growth.
- 84. A process for preparing a semiconductor member according to Claim 77, wherein said third non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitabilal method, the plasma CVD method, the low pressure CVD method, the plot to the third processor of the plasma CVD method of the blassputtening method.
- 85. A process for preparing a semiconductor member according to Claim 77, wherein said porous monocrystalline semiconductor region is obtained by anodization.
- A process for preparing a semiconductor member according to Claim 85, wherein said anodization is carried out in an HF solution.
- 87. A process for preparing a semiconductor member according to Claim 70, wherein said third non-porous monocrystalline semiconductor region is intrinsic or N-type.

- A process for preparing a semiconductor member according to Claim 87, wherein said N-type silicon is formed by epitaxial growth.
- 89. A process for preparing e semiconductor member according to Claim 77, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material.
  - 90. A process for preparing e semiconductor member according to Claim 77, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.
  - 91. A process for preparing e semiconductor member comprising the steps of:
    - forming a second monocrystalline semiconductor region of a second electroconduction type on e first monocrystalline semiductor region of a first electroconduction type, making said first monocrystalline semicon-

making said first monocrystalline semiconductor region porous to form e porous single crysalline semiconductor region,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of said second single crystilline semiconductor region, and

removing said porous monocrystalline semiconductor region by etching.

- 92. A process for preparing e semiconductor member according to Claim 91, wherein said monocrystalline semiconductor comprises sili-
- 93. A process for preparing e semiconductor member according to Claim 91, wherein said first monocrystalline semiconductor region is P-type.
  - 94. A process for preparing a semiconductor member according to Claim 91, wherein said bonding step is carried out in an atmosphere containing nitrogen.
  - 95. A process for preparing e semiconductor member according to Claim 91, wherein said bonding step includes a heat treatment in an atmosphere containing nitrogen.
  - 96. A process for preparing a semiconductor member according to Claim 91, wherein seld second non-porous monocrystalline semiconductor region is formed by opitaxial growth.
  - 97. A process for preparing a semiconductor

member according to Claim 91, wherein said second non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitaxial method, the plasma CVD method, the ow pressure CVD method, the photo CVD method, the liquid phase growth method or the biassputering method

- A process for preparing a semiconductor member according to Claim 91, wherein said porous monocrystalline semiconductor region is obtained by anodization.
- A process for preparing a semiconductor member according to Claim 98, wherein said anodization is carried out in an HF solution.
- 100.A process for preparing a semiconductor member according to Claim 92, wherein said second non-porous monocrystalline semiconductor region is intrinsic or N-type.
- 101.A process for preparing a semiconductor member according to Claim 100, wherein said N-type silicon is formed by epitaxial growth.
- 102.A process for preparing a semiconductor member according to Claim 91, wherein the member of which the surface is constituted of an insulating substance comprises a light-transmissive material
- 103.A process for preparing a semiconductor member according to Claim 91, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.
- 104.A process for preparing a semiconductor member comprising the steps of:

forming a second monocrystalline semiconductor region of a second electroconduction type on a first monocrystalline semiconductor region of a first electroconduction type,

making said first monocrystalline semiconductor region porous to form a porous monocrystalline semiconductor region,

forming a region constituted of an insulating substance on said second monocrystalline semiconductor region side,

bonding the surface of a member of which the surface is formed of an insulating substance onto the surface of said region constituted of an insulating substance, and

removing said porous monocrystalline semiconductor region by etching.

- 105.A process for preparing a semiconductor member according to Claim 104, wherein said monocrystalline semiconductor comprises silicon.
- 106.A process for preparing a semiconductor member according to Claim 104, wherein said first non-monocrystalline semiconductor legion is P-type.
- 107.A process for preparing a semiconductor member according to Claim 104, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.
  - 108.A process for preparing a semiconductor member according to Claim 104, wherein said bonding step is carried out in an atmosphere containing nitrogen.
  - 109.A process for preparing a semiconductor member according to Claim 104, wherein said bonding stap includes a heat treatment in an atmosphare containing nitrogen.
- 110.A process for preparing a semiconductor member according to Claim 104, wherein said second non-porous monocrystalline semiconductor region is formed by epitaxial growth.
- 111.A process for preparing a semiconductor member according to Calam 104, wherein said second non-porous monocrystalline semiconductor region is formed according to the method selected from the molecular beam epitadial method, the plasma CVD method, the low pressure CVD method, the ploto CVD method, the liquid phase growth method or the blassputering method.
- 112.A process for preparing a semiconductor member according to Claim 104, wherein said porous monocrystalline semiconductor region is obtained by anodization.
  - 113.A process for preparing a semiconductor member according to Claim 112, wherein said anodization is carried out in an HF solution.
- 50 114.A process for preparing a semiconductor member according to Claim 105, wherein said second non-porous monocrystalline, semiconductor region is intrinsic or N-type.
- s 115.A process for preparing a semiconductor member according to Claim 114, wherein said N-type silicon is formed by proton irradiation or epitaxial growth.

- 116.A process for preparing a semiconductor member according to Claim 104, wherein the member of which the surface is constituted or an insulating substance comprises a light-transmissive material.
- 117.A process for preparing a semiconductor member according to Claim 104, wherein the member of which the surface is constituted of an insulating substance is a silicon substrate with its surface being oxidized.
- 118.A semiconductor member comprising:
  - a first member having a non-porous monocrystalline semiconductor region on a porous monocrystalline semiconductor region, and
  - a second member having the surface constituted of an Insulating substance bonded onto the surface of said non-porous monocrystalline semiconductor region.
- 119.A semiconductor member according to Claim 118, wherein said monocrystalline semiconductor comprises silicon.
- 120.A semiconductor member according to Claim 118, wherein said porous monocrystalline semiconductor region is P-type.
- 121.A semiconductor member according to Claim 118, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.
- 122.A semiconductor member comprising:
  - a first member having a non-porous monocrystalline semiconductor region and a region constituted of an insulating substance arranged in this order on a porous monocrystalline semiconductor region, and
  - a second member bonded through a region constituted of an insulating substance onto the surface of said region constituted of the insulating substance.
- 123.A semiconductor member according to Claim 122, wherein said monocrystalline semiconductor comprises silicon.
- 124.A semiconductor member according to Claim 122, wherein said porous monocrystalline semiconductor region is P-type.
- 125.A semiconductor member according to Claim 122, wherein said non-porous monocrystalline semiconductor region has a thickness of 50 microns or less.

- 126.A semiconductor member having a non-porous silcon monocystalline semiconductor region arranged on a region constituted of an insulating substance, characterized in that the dislocation defect density in said non-porous sillicon monocrystalline semiconductor region is 2.0 x 10<sup>1</sup>/cm<sup>2</sup> or less, and the life time of carriers is 5.0 x 10<sup>2</sup> seor cropper.
- 127.A semiconductor member having a non-porous silicon monocystalline semiconductor region arranged on a region constituted of an insulating substance, characterised in that the dislocation defect density in said non-porous silicon monocystalline semiconductor region is 2.0 x 10<sup>4</sup>cm<sup>2</sup> or less, and the life time of cardres is 50 x 10<sup>-4</sup> see or longer, and also the difference between the maximum value and the minimum value of thickness of said silicon monocystalline semiconductor region is 10% or less based on said maximum value.

